(12)

DNA 3964F-15

THE ROSCOE MANUAL

Volume 15-Ambient Geomagnetic Field

Science Applications, Inc
1200 Prospect Street
La Jolla, California 92037

13 June 1975

Final Report for Period 1 March 1974—31 January 1975

CONTRACT No. DNA 001-74-C-0182

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODES B322074464 S99QAXHC06428 AND
B322075464 S99QAXHC06432 H2590D.

Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

Destroy this report when it is no longer needed. Do not return to sender.

(9) Final rpt. 1 Mar 74-31 Jan 75

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1 REPORT NUMBER (18) DNA 3964F-15 (14)	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) THE ROSCOE MANUAL Volume 15 Ambient Geomagnetic Field	5. TYPE OF REPORT & PERIOD COVERED: Final Report for Period 1 Mar 74 — 31 Jan 75
	6 PERFORMING ORG. REPORT NUMBER: SAI-75-609-LJ-3
7 AUTHOR(s) (10) Robert W. Lowen, Curtis A. Smith (15)	8. CONTRACT OR GRANT NUMBER(s): DNA 001-74-C-0182
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Science Applications, Inc. 1200 Prospect Street La Jolla, California 92037	10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NWED Subtasks S99QAXHC064-28 S99QAXHC064-32
11 CONTROLLING OFFICE NAME AND ADDRESS: Director Defense Nuclear Agency Washington, D.C. 20305 (11)	12. REPORT DATE: 13 June 1975
	13. NUMBER OF PAGES: 70 (12) 67 pp.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (16) S99QAXH (17) C064	15. SECURITY CLASS (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18 SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Codes B322074464 S99QAXHC06428 and B322075464 S99QAXHC06432 H2590D.

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

ROSCOE
Ambient Geomagnetic Model

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

A preliminary model of the ambient geomagnetic field has been adopted for use in ROSCOE. The model fits a locally-best earth-centered dipole field in the battle space; this dipole field is then used for subsequent field evaluations and line tracings. Herein are presented derivations, flow diagrams, Fortran listings, and a test problem and evaluation. The model is found to be both fast and accurate.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

402754

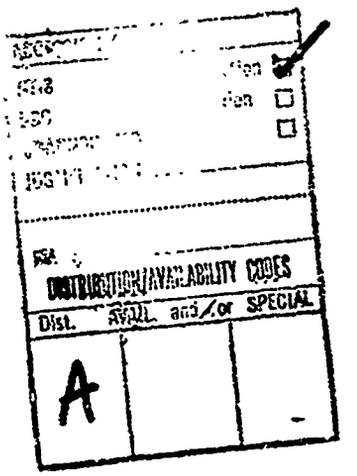
18. SUPPLEMENTARY NOTES (Continued)

EDITORS' NOTE

Volumes 13 to 17 were originally published by SAI to describe the atmospheric, geomagnetic, and high-altitude energy deposition and neutral heave models for ROSCOE. This whole section of code, when associated with an appropriate DRIVER subroutine, operated as a package that ran independently of the rest of the ROSCOE structure. Provision was also made, within this high-altitude package, for two completely independent descriptions of atmospheric heave, each with its own description of atmospheric chemistry.

When GRC incorporated this section of code within the ROSCOE framework, some modifications were necessary, which means that some of the descriptions in Volumes 13 to 17 are inappropriate to ROSCOE as it now exists. In particular, the NRL heave routines (deck NRLHYD) and associated chemistry (deck NRLCHM) are not presently used in ROSCOE. Three other subroutines are different: subroutines ATMOSU, EIF, and XTCOEF correspond to the ROSCOE subroutines ATMOS, EXPINT, and WDXP respectively. With these exceptions, the subroutines described in Volumes 13 to 17 correspond exactly to those currently in ROSCOE.

CONTENTS



ILLUSTRATIONS

TABLES

1. INTRODUCTION

The geomagnetic field plays an important role in a number of high-altitude nuclear explosion phenomena, including debris-air coupling, the guiding of beta rays and energetic ions down into the atmosphere, and the formation of striations, to mention a few. For first bursts, and sufficiently late after any burst, this field will be the ambient geomagnetic field. Accordingly, a model of the ambient geomagnetic field is needed for the new radar and optical systems code.

The requirements of such a model, apart from the general ones of modularity and minimal demands on computer storage and running time, are that it provide reasonably accurate values of the vector field components, and that it permit the efficient tracing of field lines.

The RANC codes used an earth-centered dipole approximation to the ambient geomagnetic field. Such a model is certainly fast, and permits the easy tracing of field lines, but its predictions are of low accuracy. On the other hand, there are available highly-accurate multipole field models [SM-72e] that are fast-running except for their field-line tracing routines, which necessarily integrate numerically.

Because of the fact that the systems code will be concerned with only a limited battle space of the order of one thousand kilometers in linear dimension, a compromise solution incorporating the best features of both kinds of model becomes possible; it has been explored and is tentatively adopted. This model uses accurate field components obtained from the multipole model for some point in the middle of the battle space to fit a locally-best geocentric dipole field. This, of course, needs to be done only once, during problem setup. The dipole

model is then used for subsequent field evaluations, for line tracing, and so on. Thus both speed and good accuracy are obtained.

In the following sections there is a description of a set of computer subroutines that have been written to implement the model. Listings, cross-reference lists of variables, and input/output lists are included in an appendix, along with test problems that have been used in model evaluation.

2. SUBROUTINE ONEMG5 AND LINTRA

Personnel of the National Aeronautics and Space Administration have developed and thoroughly documented [SM-72e] a set of Fortran subroutines providing a multipole-expansion model of the geomagnetic field, including secular changes and provisions for tracing field lines to intersects at specified altitudes. One of these routines, called ONEMG5,* embodies the International Geomagnetic Reference Field (IGRF 1965.0), and it has been adopted here as the "good" magnetic field model. Another routine called LINTRA traces geomagnetic field lines to their intersections with prespecified altitudes; it has been used only for verification of the simplified dipole-field line-tracing routine.

A simplified flow diagram of ONEMG5 is shown in Fig. 1. Corresponding details for LINTRA have not been supplied here, for that routine does not form part of the present package, but was only used in evaluation. Moreover, these details are readily available in SM-72e.

One note of warning must be sounded concerning the description of secular changes that is provided in CNEMG5. This description is of first order only, and is based on a fairly small number of years of good data near the epoch 1965.0. Consequently, it is inadvisable to input a time more than a few years away from the data range of the model.

*Called ONEMAG in SM-72e.

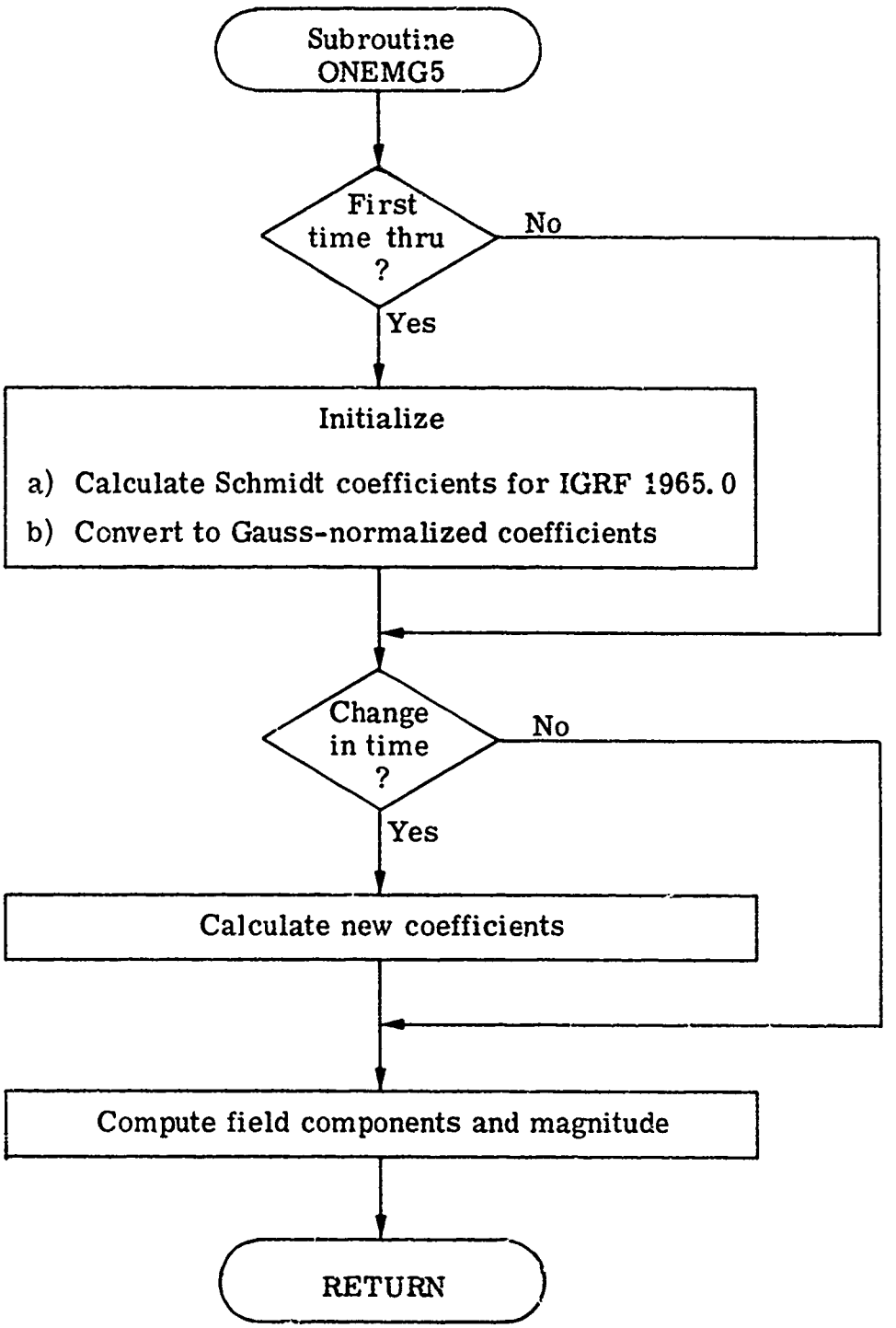


Fig. 1. Subroutine ONEMG5 Flow Diagram.

3. SUBROUTINE MAGFIT

Given a point in space (normally near the earth's surface and centrally located in the battle space) for which accurate values of the geomagnetic field components are known, subroutine MAGFIT calculates the strength and orientation of an earth-centered magnetic dipole to reproduce those components. The routine is used only once, during problem setup, and the dipole properties are then stored and used later to provide field component values at other points within the limited battle space.

In Fig. 2, the point P at geocentric radial distance r, north latitude λ (colatitude θ), and east longitude φ is the reference point at which the field components B_r, B_θ, and B_φ (in the same coordinate system (r, θ, φ) are known. The point Q at north latitude λ_0 (colatitude θ_0) and east longitude φ_0 on the surface of an earth-centered sphere passing through P is the direction of the earth-centered dipole. The point N is the north geographic pole. The arc length (or central angle) between Q and P is denoted by χ.

From the equations for a magnetic dipole field we have the relations

$$B_r = \frac{2M \cos \chi}{r^3} , \tag{1}$$

$$B_2 = \frac{M \sin \chi}{r^3} , \tag{2}$$

where M measures the dipole strength and B_2 is the angular component in the direction of increasing χ. Consequently, from simple geometry there follows the relations

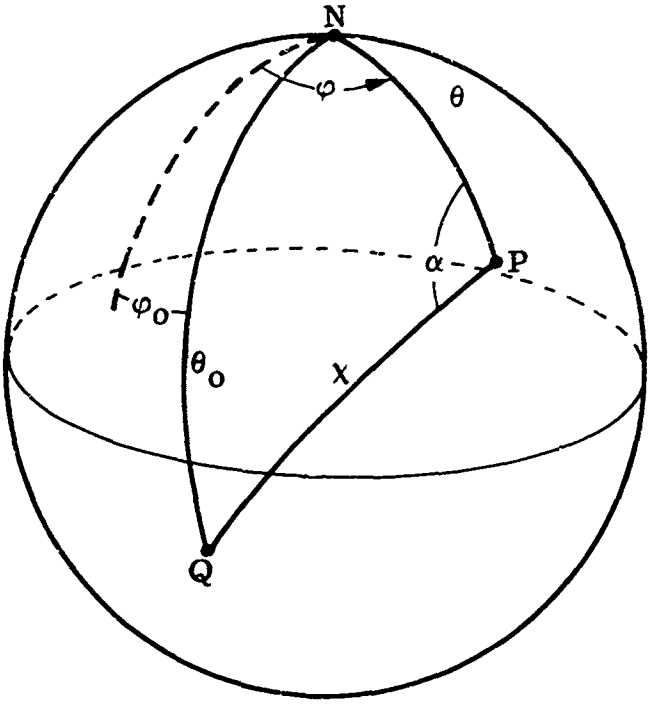


Fig. 2. Geometrical Relationships on an Earth-Centered Sphere through Point P.

$$B_\theta = B_2 \cos \alpha \ , \tag{3}$$

$$B_\varphi = B_2 \sin \alpha \ , \tag{4}$$

and

$$B_2^2 = B_\theta^2 + B_\varphi^2 \ , \tag{5}$$

where α is the angle QPN.

From Eqs. (1) and (2) one finds the formulas

$$M = \frac{r^3}{2} \left[B_r^2 + 4B_2^2 \right]^{\frac{1}{2}} \ , \tag{6}$$

$$\chi = \tan^{-1} (2B_2/B_r) \ . \tag{7}$$

From Eqs. (3) and (4) it follows that

$$\alpha = \tan^{-1} (B_\varphi/B_\theta) \ . \tag{8}$$

By applying the cosine law of spherical trigonometry to the spherical triangle QPN, one obtains the relation

$$\cos \theta_o = \cos \chi \cos \theta + \sin \chi \sin \theta \cos \alpha \ . \tag{9}$$

Application of the sine law leads to the further relation

$$\sin (\varphi - \varphi_o) = \sin \chi \sin \alpha / \sin \theta_o \ . \tag{10}$$

One more use of the cosine law yields the equation

$$\cos (\varphi - \varphi_o) = (\cos \chi - \cos \theta_o \cos \theta)/(\sin \theta_o \sin \theta) \ , \tag{11}$$

useful in establishing the correct quadrant.

Equations (5)-(11) constitute the working equations of subroutine MAGFIT. A Fortran listing of the routine appears in the appendix. A simplified flow diagram is given in Fig. 3.

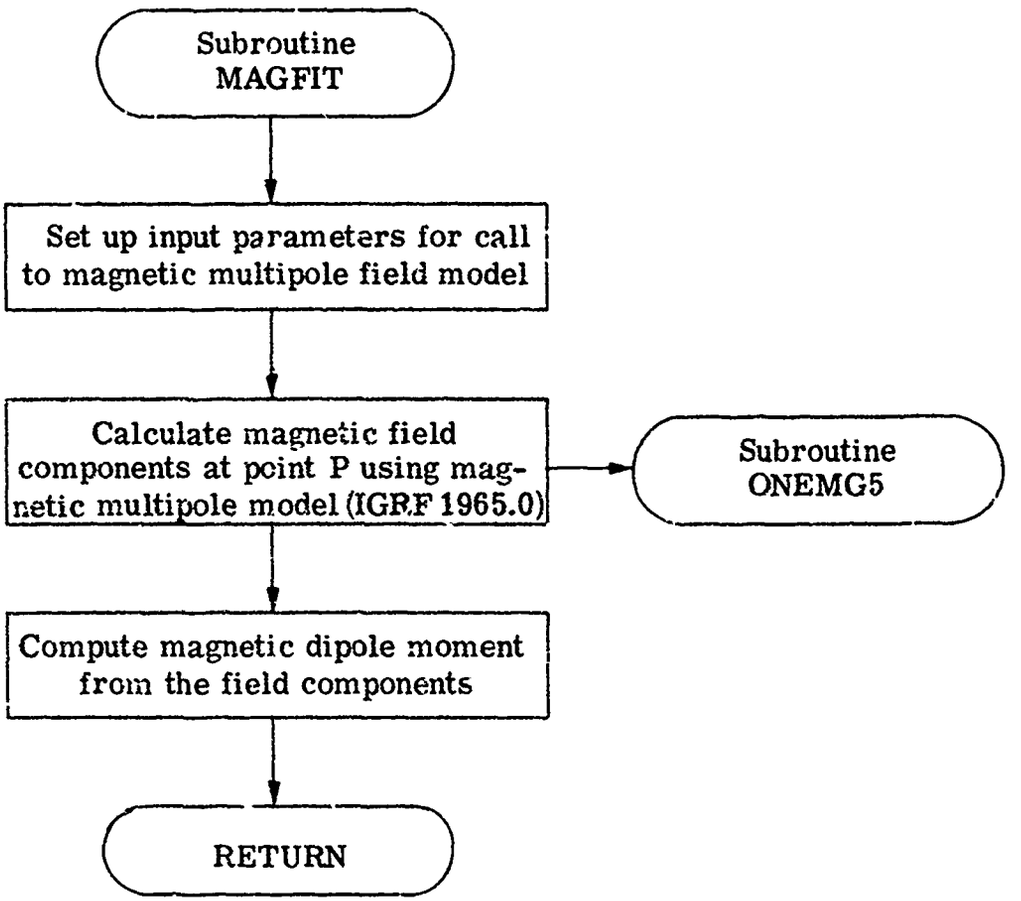


Fig. 3. Subroutine MAGFIT Flow Diagram.

4. SUBROUTINE BFIELD

For any point P at geocentric radial distance r, north latitude λ (colatitude θ), and east longitude φ, subroutine BFIELD calculates the geomagnetic field strength B, the dip angle I, and the declination angle D, based on a locally-fitted geocentric magnetic dipole of strength M oriented in the direction of north latitude λ_0 (colatitude θ_0) and east longitude φ_0. These latter three quantities must have been found previously by the use of subroutines MAGFIT and ONEMG5 for a reference point within a thousand kilometers or so of point P, if good accuracy is to be assured. Figure 2 may be used to help visualize the geometrical relationships.

The equations of subroutine BFIELD are, for the most part, just those presented above in Section 3, but solved for different variables. Thus, the angle χ between the dipole moment and the field point is obtained from the equation

$$\cos \chi = \cos \theta \cos \theta_0 + \sin \theta \sin \theta_0 \cos (\varphi - \varphi_0) \quad , \tag{12}$$

which follows from spherical trigonometry. The total field strength B is obtained by use of Eqs. (1) and (2) from the relation

$$B = \left[B_r^2 + B_2^2\right]^{\frac{1}{2}} \tag{13}$$

$$= \frac{M}{r^3}\left[3 \cos^2\chi + 1\right]^{\frac{1}{2}} \quad . \tag{14}$$

The dip angle I is obtained by use of Eqs. (1) and (2) and the definition

$$\sin I \equiv B_r/B \tag{15}$$

$$= 2 \cos \chi / \left[3 \cos^2\chi + 1\right]^{\frac{1}{2}} \quad . \tag{16}$$

The declination angle D is obtained by use of the definition

$$D \equiv \pi - \alpha \tag{17}$$

and Eqs. (10) and (9) through the equations

$$\sin D = \sin \theta_o \sin (\varphi - \varphi_o)/\sin \chi \ , \tag{18}$$

$$\cos D = (\cos \theta_o - \cos \chi \cos \theta)/(\sin \chi \sin \theta) \ , \tag{19}$$

both equations being necessary to resolve quadrant ambiguities.

Equations (14), (16), (18), and (19) are the working equations of subroutine BFIELD. A Fortran listing of the routine appears in the appendix. A simplified flow diagram is shown in Fig. 4.

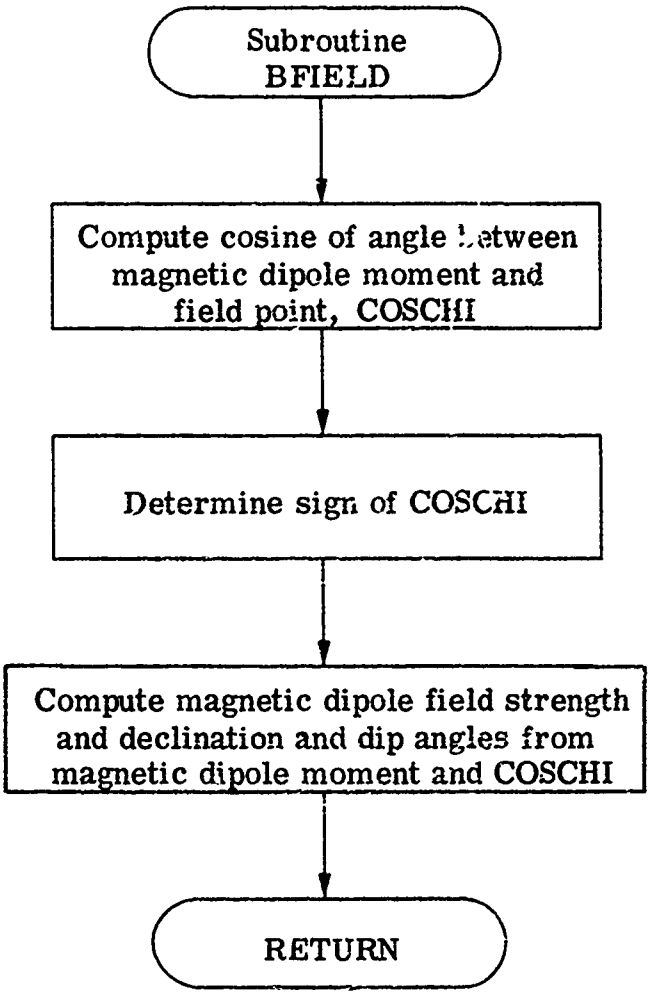


Fig. 4. Subroutine BFIELD Flow Diagram.

5. SUBROUTINE CONJUG

The main function of subroutine CONJUG is to locate the latitudes and longitudes of those points where a given geocentric magnetic dipole field line intersects a prespecified altitude. There are generally two such points; the routine will locate either, depending on the choice of an input quantity. CONJUG also computes (1) the dimensionless field-line distance (in units of the equatorial radius to the dipole field line) between two specified points P_1 and P_2 and (2) the ratio of the equatorial field to that at point P_1, for the same field line.

Suppose the orientation of the geocentric dipole is specified by the north latitude λ_o (colatitude θ_o) and east longitude φ_o. Let the field line be specified by the fact that it passes through a point P_1 in space at altitude h_1, north latitude λ_1 (colatitude θ_1), and east longitude φ_1. Then we seek the north latitude λ_2 (colatitude θ_2) and east longitude φ_2 of a point P_2 on the same dipole field line as P_1. The geometry of the situation is illustrated in Fig. 5.

From the cosine law of spherical trigonometry applied to the spherical triangle $P_o P_1 N$, we obtain the result

$$\cos \chi_1 = \cos \theta_o \cos \theta_1 + \sin \theta_o \sin \theta_1 \cos (\varphi_1 - \varphi_o) \ . \qquad (20)$$

The sine law for the same triangle gives the result

$$\sin \psi = \sin \theta_1 \sin (\varphi_1 - \varphi_o)/\sin \chi_1 \ , \qquad (21)$$

and another application of the cosine law gives the formula

$$\cos \psi = (\cos \theta_1 - \cos \chi_1 \cos \theta_o)/\sin \chi_1 \sin \theta_o \ , \qquad (22)$$

so there is no ambiguity as to the quadrant of ψ.

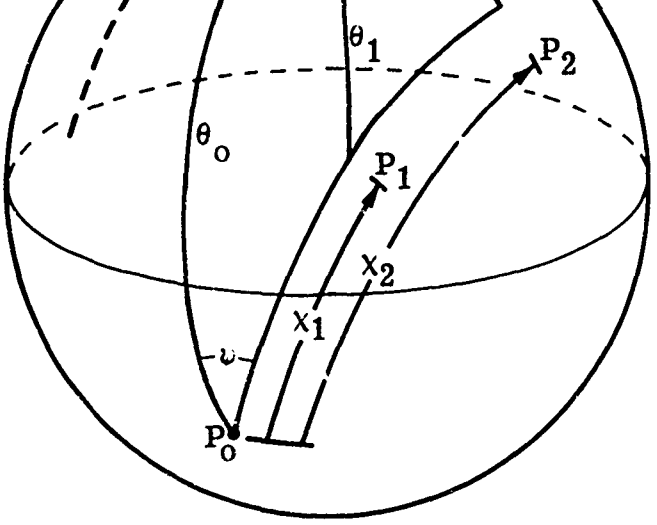


Fig. 5. Geometrical Relationships for the Field-Line Intersection Problem.

The equation of a dipole field line has the form

$$r = r_o \sin^2 \chi \ , \tag{23}$$

so the requirement that P_1 and P_2 lie on the same dipole field line leads to the result

$$\sin \chi_2 = \sin \chi_1 \left[(R_e + h_2)/(R_e + h_1)\right]^{\frac{1}{2}} \ , \tag{24}$$

where R_e is the radius of the earth and h_2 is the prespecified altitude of point P_2. Note that there are, generally, two solutions for χ_2, since if χ_2 is a solution, so is $\pi - \chi_2$.

Now, applying the sine and cosine laws to spherical triangle $P_o P_2 N$ leads to the results

$$\cos \theta_2 = \cos \theta_o \cos \chi_2 + \sin \theta_o \sin \chi_2 \cos \psi \tag{25}$$

and

$$\sin (\varphi_2 - \varphi_o) = \sin \chi_2 \sin \psi / \sin \theta_2 \ , \tag{26}$$

whence θ_2 (or λ_2) and φ_2 can be obtained.

The absolute value of the dimensionless field-line distance between points P_1 and P_2 is

$$S_{12} = \frac{1}{r_o} \left| \int_{s_1}^{s_2} ds \right| \ , \tag{27}$$

where the element of arc length is given by

$$\frac{ds}{d\chi} = r_o \sin \chi \, (1 + 3 \cos^2 \chi)^{\frac{1}{2}} \ . \tag{28}$$

After substituting Eq. (28) into (27) and performing the integration, we obtain

$$S_{12} = \frac{\sqrt{3}}{6}\left|\eta_1\sqrt{1+\eta_1^2} - \eta_2\sqrt{1+\eta_2^2} + \ln\left(\frac{\eta_1+\sqrt{1+\eta_1^2}}{\eta_2+\sqrt{1+\eta_2^2}}\right)\right| , \qquad (29)$$

where

$$\eta_1 = \sqrt{3}\cos\chi_1 \qquad (30a)$$

$$\eta_2 = \sqrt{3}\cos\chi_2 . \qquad (30b)$$

Equation (29) is valid provided points P_1 and P_2 are in the same hemisphere. If points P_1 and P_2 are in opposite hemispheres, then we must perform the integration in two parts, with the equator being the intermediate point. The result may be expressed in the form

$$S_{12} = \frac{\sqrt{3}}{6}\left|S_{1E} - AJUG \times S_{2E}\right| , \qquad (31a)$$

where

$$S_{1E} = \left|\eta_1\sqrt{1+\eta_1^2} + \ln\left(\eta_1+\sqrt{1+\eta_1^2}\right)\right| \qquad (31b)$$

$$S_{2E} = \left|\eta_2\sqrt{1+\eta_2^2} + \ln\left(\eta_2+\sqrt{1+\eta_2^2}\right)\right| , \qquad (31c)$$

and AJUG is a parameter equal to (+1) if Points P_1 and P_2 are in the same hemisphere and equal to (-1) if Points P_1 and P_2 are in opposite hemispheres.

The equatorial radius, r_o, is given by

$$r_o = (M/B_o)^{\frac{1}{3}} , \qquad (32)$$

where the equatorial value of the field, B_o, is related to the field $B(r,\chi)$ by the expression

$$B_o \equiv B(r_o, \chi=\pi/2) = \frac{\sin^6\chi}{(1+3\cos^2\chi)^{\frac{1}{2}}} B(r,\chi) \quad . \tag{33}$$

Equations (20)-(22), (24)-(26), and (31)-(33) are the working equations of subroutine CONJUG. A simplified flow diagram of the routine is presented in Fig. 6. A Fortran listing is given in the appendix.

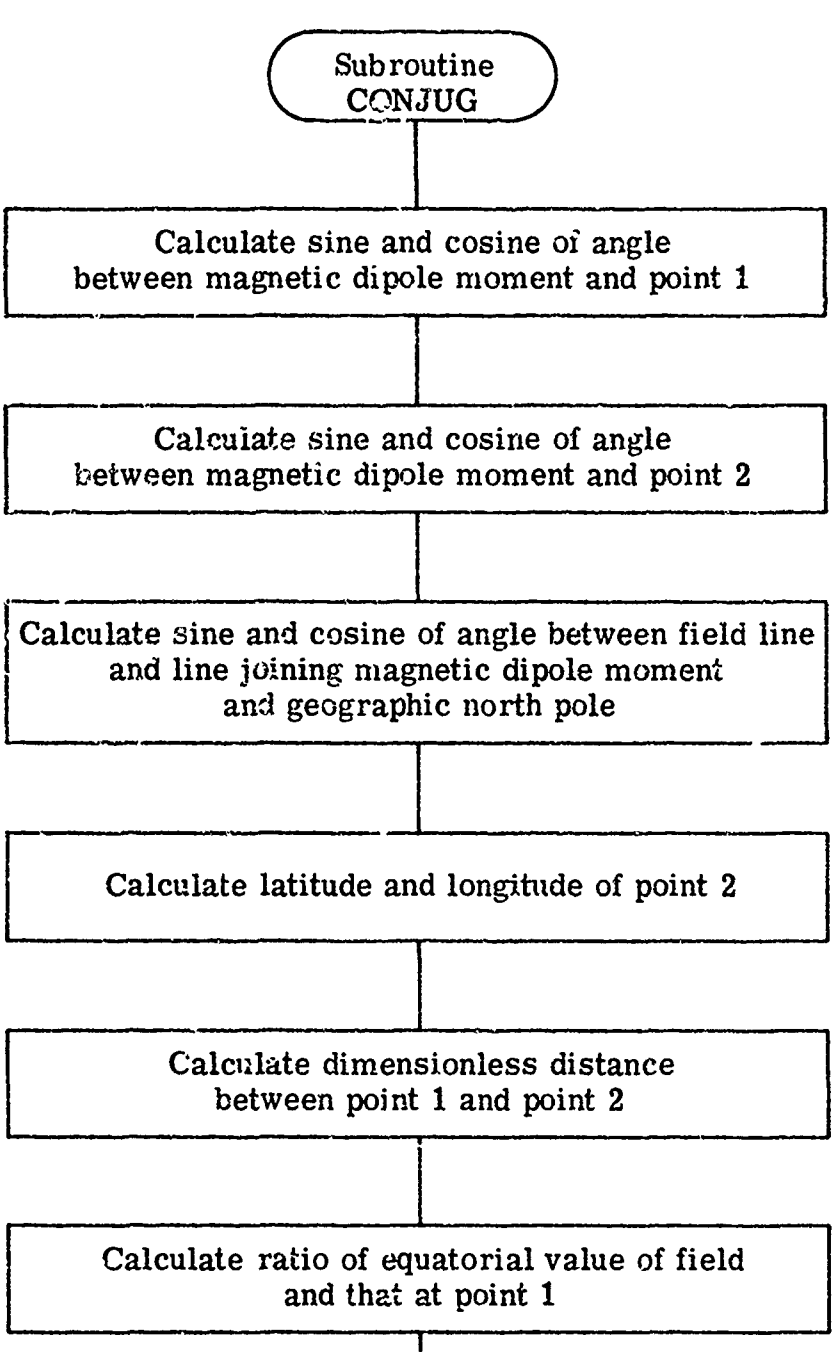


Fig. 6. Subroutine CONJUG Flow Diagram.

6. SUBROUTINE MAGDRV AND VERIFICATION TESTS OF THE AMBIENT GEOMAGNETIC FIELD MODEL

To permit the exercise of the ambient geomagnetic field model for purposes of testing and validation, a special driver routine called MAGDRV has been written. The required input consists of latitude, longitude, and altitude coordinates of a set of reference locations, at each of which the vector field of a geocentric magnetic dipole is fitted to an accurate multipole field, for a specified year. Further input consists in a set of locations, relative to each reference point, for which both the dipole field and the accurate multipole field are evaluated and compared for relative accuracy of the total field strength. Additional input consists in sets of altitudes for the calculation of field-line intersects for each of the test points, together with flags indicating whether the desired intersection is in the same or opposite magnetic hemisphere. Additional output consists in the inclination and declination angles for each test point, according to the fitted dipole model.

The principal testing carried out so far and described herein was for a set of reference points at 200-km altitude, distributed over $-60°(30°)60°$ in north latitude and $0°(60°)300°$ in east longitude. For each of these, a set of test points at 200-km altitude was specified with offsets in latitude of $+5°$, $0°$, $-5°$ and in longitude of $+10°$, $0°$, $-10°$ (a total of nine test points for each reference point). A field-line intersection altitude of 60-km altitude was called out, in separate runs for both the near and far magnetic hemisphere. (One additional reference point with a set of test points near the south magnetic pole was also run.) A check on the field-line intersection locations was provided by separate runs of the LINTRA routine.

The results of the field-strength comparisons are illustrated in Fig. 7 in the form of a histogram of the distribution of errors. It will be seen that the standard deviation is of the order of 1-2 percent. However, some test locations were found where the error was considerably larger than this. The geomagnetic field has considerable deviations from a dipole in some parts of the world. Nevertheless, it is felt that the fitted dipole model is of acceptable accuracy.

The results for the tests of field line intersection locations can be summarized by stating that, for intersection locations in the near magnetic hemisphere, the average latitude error was 0.038° and that in longitude, 0.019°. However, the median errors in both latitude and longitude were about 0.01°, showing again that occasional errors much larger than the average occur.

As for the location of intersection points in the opposite magnetic hemisphere, the less said the better, in general. The present ambient geomagnetic field model is a local best fit, and that is not a procedure that gives a good fit in the large.

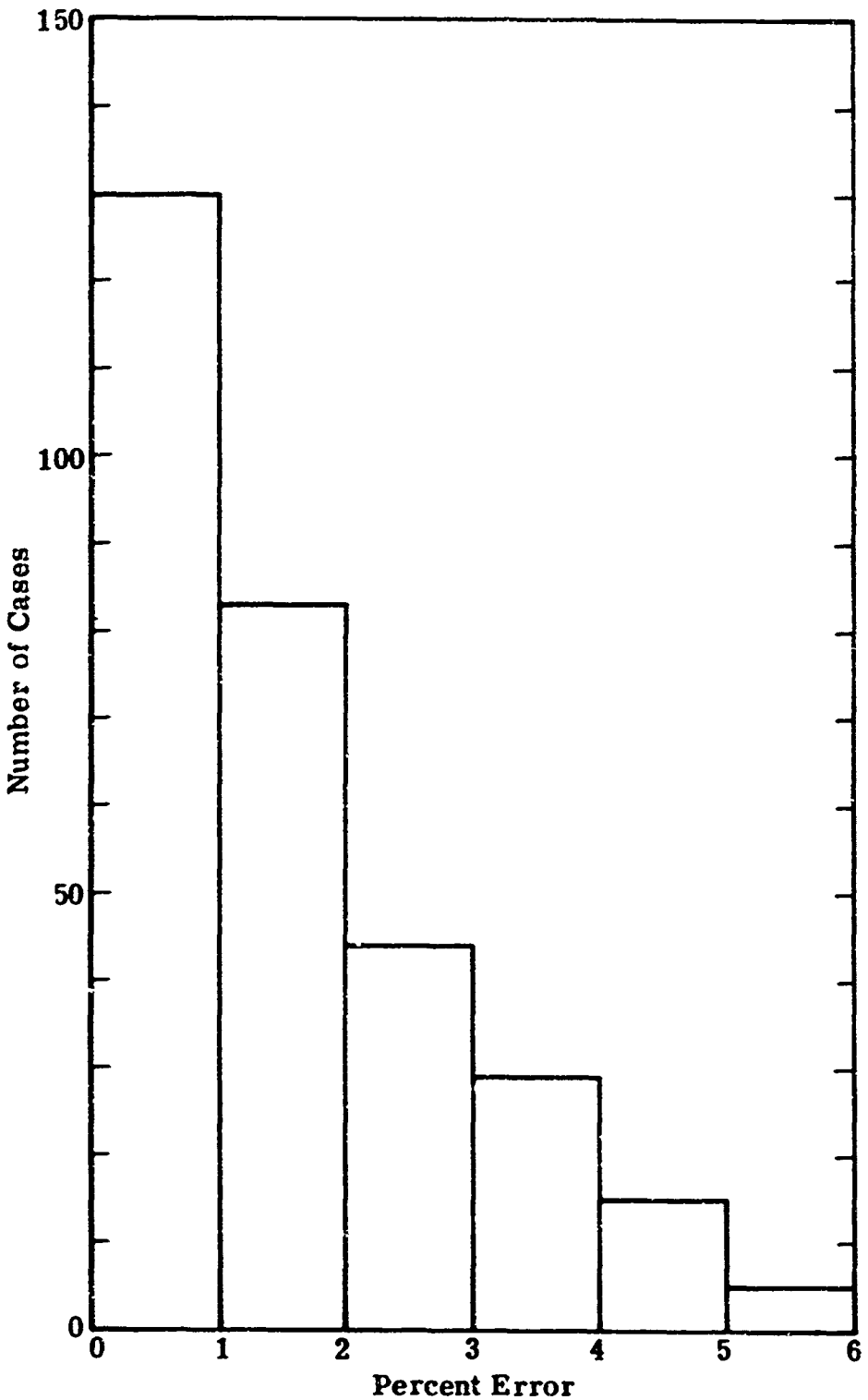


Fig. 7. Frequency Distribution of Errors in Total Field Strength.

7. REFERENCES

SM-72e E. G. Stassinopoulos and G. D. Mead, ALLMAG, GDALMG, LINTRA: Computer Programs for Geomagnetic Field and Field-Line Calculations, NSSDC 72-12, NASA-Goddard Space Flight Center, Greenbelt, MD 20771, February 1972.

APPENDIX

In this appendix are included certain materials of interest only to those who wish to exercise this model on their own computer, and who presumably have a Fortran card deck or tape available.

Table A1 contains a definition of the variables used in the equations of the text, and a cross reference with the Fortran names of the variables used in the listing.

Tables A2 through A6 contain lists of the input/output quantities for subroutines ONEMG5, MAGFIT, BFIELD, CONJUG, and MAGDRV.

Table A7 contains a compile-and-run listing of the whole module, together with the input and output for the test problem described in the text of the report.

Finally, Table A8 contains a summary of our experience of the running times of the various routines on a CDC 7600 computer.

Table A1. Symbols and Their Fortran Names.

Symbol	Fortran	Definition
$\sin(\lambda_o)$	SINLT0	Sine and cosine of north latitude of magnetic dipole moment
$\cos(\lambda_o)$	COSLT0	
φ_o	PHI0	East longitude of magnetic dipole moment
M	MU0	Magnetic dipole moment
λ	ANGS	North latitude of field point
φ	ANGE	East longitude of field point
r	RCUBE	Geocentric radius of field point
B_r	BR	Geocentric spherical field vector components (B_r, positive outward; B_θ, positive southward; and B_φ, positive eastward) of IGRF 1965.0 field.
B_θ	BTHETA	
B_φ	BPHI	
χ	CHI	Angle between the magnetic dipole moment vector and field point
$\cos(\chi)$	COSCHI	Cosine of angle between the magnetic dipole moment vector and field point
α	ALPHA	Angle between the magnetic dipole moment and geographic north pole
B_2^2	B2SQ	Square of the angular component of the magnetic field
I	DIPANG	Magnetic dip angle at field point
D	DECANG	Magnetic declination angle at field point
B	BVAL	Magnetic field strength at field point
R_e	RE	Radius of earth
λ_1	ALAT1	North latitude of point 1

Table A1. (Continued)

Symbol	Fortran	Definition
φ_1	ALON1	East longitude of point 1
h_1	ALT1	Altitude of point 1
h_2	ALT2	Altitude of point 2
λ_2	ALAT2	North latitude of point 2
φ_2	ALON2	East longitude of point 2
	AJUG	Flag controlling which magnetic hemisphere the location of the intersection point is calculated
$\sin(\chi_1)$	SINZ1	Sine of angle between the magnetic dipole moment vector and point 1
$\cos(\chi_1)$	COSZ1	Cosine of χ_1
$\sin(\chi_2)$	SINZ2	Sine and cosine of angle between the magnetic dipole moment vector and point 2
$\cos(\chi_2)$	COSZ2	
$\sin(\psi_1)$	SINPSI	Sine and cosine of angle between the field line and line joining the magnetic dipole moment with the north geographic pole
$\cos(\psi_1)$	COSPSI	

Table A2. ONEMG5 Subroutine Input/Output.

INPUT VARIABLES	
TM	Time in years for desired field
RKM	Geocentric distance of point (km)
ST	Sine of (geocentric) colatitude of point
CT	Cosine of (geocentric) colatitude of point
SPH	Sine of (geocentric) east longitude of point
CPH	Cosine of (geocentric) east longitude of point
OUTPUT VARIABLES	
BR	Radial field component (gauss)
BTHETA	Positive-south field component (gauss)
BPHI	Positive-east field component (gauss)
B	Total field magnitude (gauss)

Table A3. MAGFIT Subroutine Input/Output

INPUT VARIABLES

Argument List

ALATF	North latitude of specified point P (radians)
ALONF	East longitude of specified point P (radians)
ALTF	Altitude of specified point P (km)
TM	Time for desired field (years)

OUTPUT VARIABLES

MAGLNK Common

MU0	Magnetic dipole moment (gauss km^3)
COSLT0	Cosine of north latitude of magnetic dipole moment
SINLT0	Sine of north latitude of magnetic dipole moment
PHI0	East longitude of magnetic dipole moment (radians)

Table A4. BFIELD Subroutine Input/Output

INPUT VARIABLES

Argument List

ANGS	North latitude of field point (radians)
ANGE	East longitude of field point (radians)
ALT	Altitude of field point (km)

MAGLNK Common

MU0	Magnetic dipole moment (gauss km^3)
COSLT0	Cosine of north latitude of magnetic dipole moment
SINLT0	Sine of north latitude of magnetic dipole moment
PHI0	East longitude of magnetic dipole moment (radians)

OUTPUT VARIABLES

Argument List

BVAL	Magnetic dipole field strength at point (gauss)
DIPANG	Dip angle of the magnetic dipole field at point (radians)
DECANG	Declination angle of the magnetic dipole field at point (radians)
COSCHI	Cosine of angle between the magnetic dipole moment vector and field point

Table A5. CONJUG Subroutine Input/Output

INPUT VARIABLES

Argument List

ALAT1	North latitude of point 1 (radians)
ALON1	East longitude of point 1 (radians)
ALT1	Altitude of point 1 (km)
ALT2	Altitude of point 2 (km)
AJUG	1. - Calculates latitude and longitude of point 2 in same magnetic hemisphere
	-1. - Calculates latitude and longitude of point 2 in opposite magnetic hemisphere

MAGLNK Common

MU0	Magnetic dipole moment (gauss km^3)
COSLT0	Cosine of north latitude of magnetic dipole moment
SINLT0	Sine of north latitude of magnetic dipole moment
PHI0	East longitude of magnetic dipole moment (radians)

OUTPUT VARIABLES

ALAT2	North latitude of point 2 (radians)
ALON2	East longitude of point 2 (radians)
S12	Path length along the field line from point 1 to point 2 (in units of the equatorial radius of the traced field line)
BEB1	Ratio of the equatorial value of the field to that at point 1 for the traced field line

Table A6. MAGDRV Input Quantities — START Namelist

ALATFI	Array of north latitudes of fit points (deg)
ALONFI	Array of east longitudes of fit points (deg)
ALTFI	Array of altitudes of fit points (km)
NFIT	Number of fit points
TM	Time at which to evaluate exact field (years)
RLATS*	Array of north-latitude deltas of test points (deg)
RLONS*	Array of east-longitude deltas of test points (deg)
RALTS*	Array of altitude deltas of test points (km)
NRS	Number of test points relative to a fit point
RCONS	Array of test altitudes for intersection calculations (km)
AJUGS	Array of calculation options for conjugate-region intersection calculations: 1. - Calculate intersection point in same magnetic hemisphere. -1. - Calculate intersection point in opposite magnetic hemisphere.
IOPT	MAGDRV calculation options: 1 - Calculate only magnetic dipole field at test points. 2 - Also calculate location of intersection points. 3 - Also calculate magnetic multipole field at test points.

*The (input) locations of the test points are relative to the fit point.

Table A7. Compile-and-Run Listing of the Ambient Magnetic-Field Module, with Input and Output of Test Problems.

MAGDRV

```
      PROGRAM MAGDRV(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)                NEWMAG.2
C                                                                          NEWMAG.3
C  *  *  *  *                                                             NEWMAG.4
C                                                                          NEWMAG.5
C     THIS PROGRAM EXERCISES THE AMBIENT MAGNETIC FIELD MODEL.  THE        NEWMAG.6
C     MODEL CONSISTS OF FOUR ROUTINES.  MAGFIT FITS A DIPOLE FIELD TO      NEWMAG.7
C     THE MAGNETIC FIELD AT A GIVEN POINT,WHICH SHOULD BE NEAR             NEWMAG.8
C     THE CENTER OF THE REGION OF INTEREST.  THE 'EXACT' FIELD AT THE      NEWMAG.9
C     POINT IS CALCULATED FROM ONEMGS, A MODEL OF THE INTERNATIONAL        NEWMAG.10
C     GEOMAGNETIC REFERENCE FIELD, EPOCH 1965.0.                           NEWMAG.11
C     (SEE (1) E.G. STASSINOPOULOS AND G.D. MEAD, NASA REPORT              NEWMAG.12
C     NSSDC 72-12, ALLMAG,GDALMG,LINTRA  COMPUTER PROGRAMS FOR             NEWMAG.13
C     GEOMAGNETIC FIELD AND FIELD-LINE CALCULATIONS, FEBRUARY 1972         NEWMAG.14
C     AND (2) J.C. CAIN AND S.J. CAIN, NASA TN D-6237, DERIVATION          NEWMAG.15
C     OF THE INTERNATIONAL GEOMAGNETIC REFERENCE FIELD (IGRF(10/68)),      NEWMAG.16
C     AUGUST 1971.)                                                        NEWMAG.17
C     A THIRD ROUTINE, BFIELD, CALCULATES THE MAGNETIC FIELD STRENGTH      NEWMAG.18
C     FOR ANY GIVEN POINT FOR THE FITTED DIPOLE. THE FOURTH ROUTINE        NEWMAG.19
C     CALCULATES THE LOCATION OF A POINT WITH A GIVEN ALTITUDE WHICH       NEWMAG.20
C     IS ON THE SAME FIELD LINE AS SOME SPECIFIED POINT FOR THE FITTED     NEWMAG.21
C     DIPOLE FIELD.                                                        NEWMAG.22
C                                                                          NEWMAG.23
C  *  *  *  *                                                             NEWMAG.24
C                                                                          NEWMAG.25
C     INPUT PARAMETERS (NAMELIST START)                                    NEWMAG.26
C       ALATFI = ARRAY OF NORTH LATITUDES OF FIT POINTS (DEG)              NEWMAG.27
C       ALONFI = ARRAY OF EAST LONGITUDES OF FIT POINTS (DEG)              NEWMAG.28
C       ALTFI  = ARRAY OF ALTITUDES OF FIT POINTS (KM)                     NEWMAG.29
C       NFIT   = NUMBER OF FIT POINTS                                      NEWMAG.30
C       TM     = TIME AT WHICH TO EVALUATE EXACT FIELD (YEARS)             NEWMAG.31
C       RLATS  = ARRAY OF NORTH LATITUDES OF TEST POINTS (DEG)             NEWMAG.32
C       RLONS  = ARRAY OF EAST LONGITUDES OF TEST POINTS (DEG)             NEWMAG.33
C       RALTS  = ARRAY OF ALTITUDES OF TEST POINTS (KM)                    NEWMAG.34
C       NRS    = NUMBER OF TEST POINTS                                     NEWMAG.35
C       RCONS  = ARRAY OF TEST FIELD LINE ALTITUDES (KM)                   NEWMAG.36
C       AJUGS  = ARRAY OF TEST FIELD LINE CALCULATION OPTIONS              NEWMAG.37
C                  1.  CALCULATES INTERSECTION POINT IN SAME               NEWMAG.38
C                      MAGNETIC HEMISPERE                                  NEWMAG.39
C                 -1.  CALCULATES INTERSECTION IN OPPOSITE                 NEWMAG.40
C                      MAGNETIC HEMISPERE                                  NEWMAG.41
C     ***************************************************                  NEWMAG.42
C     *                                                 *                  NEWMAG.43
C     *  CAUTION - LOCATION OF OPPOSITE HEMISPHERE      *                  NEWMAG.44
C     *            INTERSECTIONS MAY NOT BE ACCURATE    *                  NEWMAG.45
C     *                                                 *                  NEWMAG.46
C     ***************************************************                  NEWMAG.47
C       IOPT   = CALCULATION OPTIONS                                       NEWMAG.48
C                  1 = CALCULATE ONLY DIPOLE B FIELD AT TEST POINTS        NEWMAG.49
C                  2 = ALSO CALCULATE LOCATION OF INTERSECTION POINTS      NEWMAG.50
C                  3 = ALSO CALCULATE MULTIPOLE B FIELD AT TEST POINTS     NEWMAG.51
C                                                                          NEWMAG.52
C  FIT DIPOLE TO POINT                                                     NEWMAG.53
C                                                                          NEWMAG.54
      REAL MUO                                                             NEWMAG.55
C                                                                          NEWMAG.56
      COMMON /MAGLNK/ MUO,COSLTO,SINLTO,PHIO                               NEWMAG.57
```

MAGDRV (Cont'd)

```
      COMMON/CNSINT/ RECM,PI,HALFPI,FOURPI,GRAVZ(7)                          NEWMAG,58
C                                                                            NEWMAG,59
      DIMENSION RLATS(50),RLONS(50),RCONS(50),AJUGS(50)                      NEWMAG,60
      DIMENSION RALTS(50)                                                    NEWMAG,61
      DIMENSION ALATFI(50),ALONFI(50),ALTFI(50)                              NEWMAG,62
C                                                                            NEWMAG,63
      NAMELIST /START/ALATFI,ALONFI,ALTFI,NFIT,TM,RLATS,RLONS,RALTS,NRS,     NEWMAG,64
     $RCONS,AJUGS,IOPT                                                       NEWMAG,65
C                                                                            NEWMAG,66
      RE = 1.0E+05*RECM                                                      NEWMAG,67
4     RADS = HALFPI/90.                                                      NEWMAG,68
C                                                                            NEWMAG,69
C  READ IN DATA                                                              NEWMAG,70
C                                                                            NEWMAG,71
6     READ(5,START)                                                          NEWMAG,72
11    WRITE(6,START)                                                         NEWMAG,73
C                                                                            NEWMAG,74
C  LOOP OVER FIT POINTS                                                      NEWMAG,75
C                                                                            NEWMAG,76
14    DO 900 JJ=1,NFIT                                                       NEWMAG,77
17    ALATF = ALATFI(JJ)                                                     NEWMAG,78
20    ALONF = ALONFI(JJ)                                                     NEWMAG,79
21    ALTF = ALTFI(JJ)                                                       NEWMAG,80
23    WRITE(6,1000)ALATF,ALONF,ALTF,TM                                       NEWMAG,81
37    ALATF = ALATF*RADS                                                     NEWMAG,82
41    ALONF = ALONF*RADS                                                     NEWMAG,83
1000  FORMAT(1H1,33H LOCATION OF POINT THAT IS FITTED,//,12H LATITUDE  =     NEWMAG,84
     $,F9.2,6H (DEG),/,13H LONGITUDE = ,F8.2,6H (DEG),/,13H ALTITUDE  =     NEWMAG,85
     $,F8.2,6H (DEG),/,13H TIME      = ,F8.2,6H (YRS),///)                  NEWMAG,86
C                                                                            NEWMAG,87
C  FIT DIPOLE TO GIVEN FIELD POINT                                           NEWMAG,88
C                                                                            NEWMAG,89
42    CALL MAGFIT(ALATF,ALONF,ALTF,TM)                                       NEWMAG,90
45    WRITE(6,1001)MU0,COSLT0,SINLT0,PHI0                                    NEWMAG,91
1001  FORMAT(//,25H FITTED DIPOLE PARAMETERS,//,10H MU0    = ,E13.6,       NEWMAG,92
     $13H  GAUSS KM**3,/,10H COSLT0 = ,E13.6,/,10H SINLT0 = ,E13.6,/,       NEWMAG,93
     $10H PHI0   = ,E13.6,26H  LONGITUDE EAST (RADIANS),///)                NEWMAG,94
61      10 WRITE(6,1002)                                                     NEWMAG,95
1002  FORMAT(1H+,1X,9H TEST LAT,2X,9H TEST LON,1X,9H TEST ALT,2X,            NEWMAG,96
     $ 9H DIPOLE B,1X,7H DIPANG,3X,7H DECANG)                                NEWMAG,97
65      IF(IOPT .LT. 2) GO TO 50                                             NEWMAG,98
70      20 WRITE(6,1003)                                                     NEWMAG,99
1003  FORMAT(1H+,62X,10HINTERS ALT,2X,6H AJUG ,4X,10HINTERS LAT,2X,          NEWMAG,100
     $10HINTERS LON)                                                         NEWMAG,101
74      IF (IOPT .LT. 3)GO TO 50                                             NEWMAG,102
77      30 WRITE(6,1004)                                                     NEWMAG,103
1004  FORMAT(109X,7H IGRF B,2X,8H PERCENT)                                   NEWMAG,104
103     50 CONTINUE                                                          NEWMAG,105
C                                                                            NEWMAG,106
C  LOOP OVER TEST POINTS                                                     NEWMAG,107
C                                                                            NEWMAG,108
103     DO 400 J=1,NRS                                                       NEWMAG,109
C                                                                            NEWMAG,110
C  CALCULATE DIPOLE FIELD VALUE AT TEST POINT                                NEWMAG,111
C                                                                            NEWMAG,112
106     ANGS = ALATF + RLATS(I)*RADS                                         NEWMAG,113
```

MAGDRV (Cont'd)

```
110         ANGF = ALONF + RLONS(J)*RADS                                    NEWMAG,114
113         ALT = ALTF + RALTS(J)                                           NEWMAG,115
115         CALL BFIELD(ANGS,ANGE,ALT,B,DIPANG,DECANG,COSCHI)               NEWMAG,116
120         ANGSD = ANGS / RADS                                             NEWMAG,117
126         ANGED = ANGE / RADS                                             NEWMAG,118
127         DIPANG = DIPANG / RADS                                          NEWMAG,119
131         DECANG = DECANG / RADS                                          NEWMAG,120
132         WRITE(6,1005) ANGSD,ANGED,ALT,B,DIPANG,DECANG                   NEWMAG,121
       1005 FORMAT(1H+,3(2X,F8.2),2X,F8.3,3X,F7.2,2X,F8.2)                  NEWMAG,122
152         IF(IOPT .LE. 1)GO TO 400                                        NEWMAG,123
      C                                                                     NEWMAG,124
      C  CALCULATE LOCATION OF POINTS AT ALTITUDE RCONS WHICH ARE ON  HE SAME NEWMAG,125
      C  FIELD LINE AS THE TEST POINT                                       NEWMAG,126
      C                                                                     NEWMAG,127
156         AJUG = AJUGS(J)                                                 NEWMAG,128
157         ALT2=RCONS(J)                                                   NEWMAG,129
161         CALL CONJUG(ANGS,ANGE,ALT,ALT2,AJUG,ALA2,ALO2,S12,BEB1)         NEWMAG,130
171         ALA2=ALA2/RADS                                                  NEWMAG,131
173         ALO2=ALO2/RADS                                                  NEWMAG,132
174         WRITE(6,1006)ALT2,AJUG,ALA2,ALO2                                NEWMAG,133
       1006 FORMAT(1H+,60X,F10.2,F9.2,4X,2(F10.3,2X))                       NEWMAG,134
207         IF(IOPT .LE. 2) GO TO 400                                       NEWMAG,135
      C                                                                     NEWMAG,136
      C  CALCULATE *EXACT* FIELD FROM IGRF(1965.) AT TEST POINT             NEWMAG,137
      C                                                                     NEWMAG,138
212         RKM = RF + ALT                                                  NEWMAG,139
213         COLAT = HALFPI-ANGS                                             NEWMAG,140
216         ST = SIN(COLAT)                                                 NEWMAG,141
217         CT = COS(COLAT)                                                 NEWMAG,142
221         SPH = SIN(ANGF)                                                 NEWMAG,143
223         CPH = COS(ANGE)                                                 NEWMAG,144
226         CALL ONEMGS(TM,RKM,ST,CT,SPH,CPH,BR,BT,BP,BEXACT)               NEWMAG,145
237         DELT =(B - BEXACT)/BEXACT*100.                                  NEWMAG,146
243         WRITE(6,1007)BEXACT,DELT                                        NEWMAG,147
       1007 FORMAT(103X,2X,F10.3,1X,F10.3)                                  NEWMAG,148
252     400 CONTINUE                                                        NEWMAG,149
255     900 CONTINUE                                                        NEWMAG,150
257         WRITE(6,1008)                                                   NEWMAG,151
       1008 FORMAT(///,20H END OF TEST PROBLEM)                             NEWMAG,152
263         STOP                                                            NEWMAG,153
265         END                                                             NEWMAG,154
```

BFIELD

```
      SUBROUTINE BFIELD(ANGS,ANGE,ALT,BVAL,DIPANG,DECANG,COSCHI)          NEWMAG,155
C                                                                         NEWMAG,156
C  *  *  *                                                               NEWMAG,157
C                                                                         NEWMAG,158
C     THIS ROUTINE CALCULATES THE AMBIENT MAGNETIC FIELD AT A POINT       NEWMAG,159
C     FROM THE MAGNITUDE AND DIRECTION OF THE MAGNETIC DIPOLE MOMENT,     NEWMAG,160
C     AND THE LOCATION OF THE POINT                                       NEWMAG,161
C                                                                         NEWMAG,162
C  *  *  *                                                               NEWMAG,163
C                                                                         NEWMAG,164
C     INPUT PARAMETERS                                                    NEWMAG,165
C       ARGUMENT LIST -                                                   NEWMAG,166
C         ANGS   - NORTH LATITUDE OF FIELD POINT (RADIANS)                NEWMAG,167
C         ANGE   - EAST LONGITUDE OF FIELD POINT (RADIANS)                NEWMAG,168
C         ALT    - ALTITUDE OF FIELD POINT (KM)                           NEWMAG,169
C                                                                         NEWMAG,170
C       MAGLNK COMMON                                                     NEWMAG,171
C         MU0    - MAGNETIC DIPOLE MOMENT (GAUSS-KM3)                     NEWMAG,172
C         COSLT0 - COSINE OF NORTH LATITUDE OF MAGNETIC DIPOLE MOMENT     NEWMAG,173
C         SINLT0 - SINE   OF NORTH LATITUDE OF MAGNETIC DIPOLE MOMENT     NEWMAG,174
C         PHI0   - EAST LONGITUDE OF MAGNETIC DIPOLE MOMENT (RADIANS)     NEWMAG,175
C       CNSTNT COMMON                                                     NEWMAG,176
C         PI     - 3.1415926535898                                        NEWMAG,177
C         RECM   - EARTH RADIUS (CM)                                      NEWMAG,178
C                                                                         NEWMAG,179
C     OUTPUT PARAMETERS                                                   NEWMAG,180
C       ARGUMENT LIST -                                                   NEWMAG,181
C         BVAL   - MAGNETIC FIELD STRENGHT AT FIELD POINT (GAUSS)         NEWMAG,182
C         DIPANG - DIP ANGLE OF MAGNETIC FIELD AT FIELD POINT (RAD),      NEWMAG,183
C                  DIP (OR INCLINATION) IS THE VERTICAL ANGLE MEASURED    NEWMAG,184
C                  FROM THE HORIZONTAL AT ANY POINT TO THE (VECTOR)       NEWMAG,185
C                  LINE OF FORCE THROUGH THAT POINT.  IT IS POSITIVE IN   NEWMAG,186
C                  THE NORTHERN MAGNETIC HEMISPHERE AND NEGATIVE IN       NEWMAG,187
C                  THE SOUTHERN MAGNETIC HEMISPHERE.                      NEWMAG,188
C         DECANG - DECLINATION OF MAGNETIC FIELD AT FIELD POINT (RAD),    NEWMAG,189
C                  DECLINATION (OR VARIATION), THE ANGLE BETWEEN THE      NEWMAG,190
C                  GEOGRAPHIC AND MAGNETIC MERIDIANS AT A POINT, IS       NEWMAG,191
C                  POSITIVE IF THE COMPASS NEEDLE POINTS EAST OF          NEWMAG,192
C                  GEOGRAPHIC NORTH.                                      NEWMAG,193
C         COSCHI - COSINE OF MAGNETIC-DIPOLE COLATITUDE.                  NEWMAG,194
C                  COSCHI IS NEGATIVE IN THE NORTHERN MAGNETIC            NEWMAG,195
C                  HEMISPHERE AND POSITIVE IN THE SOUTHERN MAGNETIC       NEWMAG,196
C                  HEMISPHERE.                                            NEWMAG,197
C                                                                         NEWMAG,198
      REAL MU0                                                            NEWMAG,199
C                                                                         NEWMAG,200
      COMMON /MAGLNK/ MU0,COSLT0,SINLT0,PHI0                              NEWMAG,201
      COMMON/CNSTNT/RECM,PI,HALFPT,FOURPI,GRAVZ,GZRE2,BOLTZK,GAM1,GM1I    NEWMAG,202
     1              ,PMNIT,PM0XY                                         NEWMAG,203
C                                                                         NEWMAG,204
      RF=RECM*1.E-5                                                       NEWMAG,205
C                                                                         NEWMAG,206
C  CALCULATE SINE AND COSINE OF NORTH LATITUDE OF FIELD POINT             NEWMAG,207
C                                                                         NEWMAG,208
12    COSLAP = COS(ANGS)                                                  NEWMAG,209
14    SINLAP = SIN(ANGS)                                                  NEWMAG,210
```

BFIELD (Cont'd)

```
21          DELLON = ANGE - PHIO                                          NEWMAG.211
      C                                                                   NEWMAG.212
      C   CALCULATE SINE AND COSINE OF ANGLE BETWEEN MAGNETIC             NEWMAG.213
      C   DIPOLE MOMENT AND FIELD POINT                                   NEWMAG.214
      C                                                                   NEWMAG.215
27          COSCHI = COSLAP*COSLTO*COS(ANGE - PHIO) + SINLAP*SINLTO       NEWMAG.216
41          SINCHI = SQRT(1. - COSCHI*COSCHI)                             NEWMAG.217
      C                                                                   NEWMAG.218
      C   CALCULATE CUBE OF GEOCENTRIC RADIUS OF POINT                   NEWMAG.219
      C                                                                   NEWMAG.220
51          RCUBE = RE + ALT                                              NEWMAG.221
53          RCUBE = RCUBE*RCUBE*RCUBE                                     NEWMAG.222
      C                                                                   NEWMAG.223
      C   TOTAL FIELD STRENGTH                                           NEWMAG.224
      C                                                                   NEWMAG.225
54          BTERM = SQRT(3.*COSCHI*COSCHI + 1.)                           NEWMAG.226
65          BVAL = MUO/RCUBE*BTERM                                        NEWMAG.227
      C                                                                   NEWMAG.228
      C   MAGNETIC DIP ANGLE AT POINT                                    NEWMAG.229
      C                                                                   NEWMAG.230
67          SINDIP = 2. * COSCHI / BTERM                                  NEWMAG.231
72          DIPANG = -ASIN(SINDIP)                                        NEWMAG.232
      C                                                                   NEWMAG.233
      C   MAGNETIC DECLINATION ANGLE AT POINT                            NEWMAG.234
      C                                                                   NEWMAG.235
77          SINPSI = COSLTO * SIN(DELLON) / SINCHI                        NEWMAG.236
103         DECANG = ASIN(SINPSI)                                         NEWMAG.237
115         COSPSI = -SINLTO + COSCHI * SINLAP                            NEWMAG.238
120         IF(COSPSI.LT.0.) DECANG = SIGN(PI,SINPSI) - DECANG            NEWMAG.239
      C                                                                   NEWMAG.240
125         RETURN                                                        NEWMAG.241
126         END                                                           NEWMAG.242
```

BLOCKH

```
      BLOCK DATA BLOCKH                                                 NEWMAG,243
C                                                                       NEWMAG,244
C     INITIALIZE NAMED COMMON CONSTANTS AND DEFAULT VALUES              NEWMAG,245
C                                                                       NEWMAG,246
C     SET OF CHEM QUANTITIES APPEARING UNDER VARIOUS CHEM OPTIONS       NEWMAG,247
C         DEPOSITION COEFFICIENTS FOR PROMPG                            NEWMAG,248
      COMMON/DEPDAT/SIGU(5,4),PREFF(5,4),ERGU(5),THRESH(4),SPINTH,      NEWMAG,249
     1              SPINT,XMU1                                          NEWMAG,250
C         MATHEMATICAL AND GEOPHYSICAL CONSTANTS                        NEWMAG,251
      COMMON/CNSTNT/RE,PI,HALFPI,FOURPI,GRAVZ,GZRE2,BOLTZK,GAM1,GM11    NEWMAG,252
     1              ,PMNIT,PMOXY                                        NEWMAG,253
C                                                                       NEWMAG,254
C         CNSTNT                                                        NEWMAG,255
      DATA      RE     /6.367650E+08/,                                  NEWMAG,256
     1          PI     /3.1415926535895/,                               NEWMAG,257
     3          HALFPI/1.5707963267949/,                                NEWMAG,258
     5          FOURPI/12.566370614359Z/,                               NEWMAG,259
     7          GRAVZ/980.665/,                                         NEWMAG,260
     5          BOLTZK/1.38054E-16/,                                    NEWMAG,261
     2          PMNIT /2.324743E-23/,                                   NEWMAG,262
     3          PMOXY /2.656A50E-23/,                                   NEWMAG,263
     6          GAM1/0.5/                                               NEWMAG,264
C         DEPDAT                                                        NEWMAG,265
      DATA SIGU /0.0     ,8.0E-18,2.0E-17,2.5E-17,2.0E-17,              NEWMAG,266
     1           2.0E-18,1.6E-17,2.0E-17,2.5E-17,2.0E-17,              NEWMAG,267
     2           0.0     ,1.0E-17,1.0E-17,1.0E-17,1.0E-17,             NEWMAG,268
     3           0.0     ,3.2E-18,3.2E-18,9.0E-18,9.0E-18/,            NEWMAG,269
     4     ERGU /1.762E-11,2.371E-11,2.595E-11,3.525E-11,5.767E-11/,    NEWMAG,270
     5     THRESH/1.564E-11,8.202E-12,2.331E-11,2.182E-11/,             NEWMAG,271
     6     SPINTH/1.00E11/,SPINT/2.07E11/                               NEWMAG,272
      END                                                               NEWMAG,273
```

CONJUG

```
      SUBROUTINE CONJUG(ALAT1,ALON1,ALT1,ALT2,AJUG,ALAT2,ALON2,S12,BEB1)NEWMAG,274
C                                                                     NEWMAG,275
C  *  *  *  *  *  *  *  *  *                                         NEWMAG,276
C                                                                     NEWMAG,277
C     THE ROUTINE CONJUG CALCULATES, FOR A GIVEN ALTITUDE, THE LOCATION NEWMAG,278
C     (LAT,LON) OF THE POINT(2), WHICH IS ON THE SAME MAGNETIC DIPOLE  NEWMAG,279
C     FIELD LINE AS SOME OTHER GIVEN POINT(1). IT ALSO CALCULATES THE  NEWMAG,280
C     FIELD-LINE DISTANCE BETWEEN POINT(1) AND POINT(2), IN UNITS OF   NEWMAG,281
C     THE EQUATORIAL RADIUS OF THE TRACED LINE, AND THE RATIO OF THE   NEWMAG,282
C     EQUATORIAL VALUE OF THE FIELD TO THAT AT POINT(1) FOR THE TRACED NEWMAG,283
C     LINE.                                                           NEWMAG,284
C                                                                     NEWMAG,285
C  *  *  *  *  *  *  *  *  *                                         NEWMAG,286
C                                                                     NEWMAG,287
C     INPUT PARAMETERS                                                NEWMAG,288
C       ARGUMENT LIST -                                               NEWMAG,289
C         ALAT1  - NORTH LATITUDE OF POINT 1 (RADIANS)                NEWMAG,290
C         ALON1  - EAST LONGITUDE OF POINT 1 (RADIANS)                NEWMAG,291
C         ALT1   - ALTITUDE OF POINT 1 (KM)                           NEWMAG,292
C         ALT2   - ALTITUDE OF POINT 2 (KM)                           NEWMAG,293
C         AJUG   -                                                    NEWMAG,294
C                  1.  CALCULATES LOCATION (LAT,LON) OF POINT 2       NEWMAG,295
C                      IN SAME     MAGNETIC HEMISPHERE                NEWMAG,296
C                 -1.  CALCULATES LOCATION (LAT,LON) OF POINT 2       NEWMAG,297
C                      IN OPPOSITE MAGNETIC HEMISPHERE                NEWMAG,298
C                                                                     NEWMAG,299
C     ***************************************************             NEWMAG,300
C     *                                                 *             NEWMAG,301
C     *  CAUTION - LOCATION OF OPPOSITE HEMISPHERE      *             NEWMAG,302
C     *            INTERSECTIONS MAY NOT BE ACCURATE    *             NEWMAG,303
C     *                                                 *             NEWMAG,304
C     ***************************************************             NEWMAG,305
C                                                                     NEWMAG,306
C       MAGLNK COMMON                                                 NEWMAG,307
C         MU0    - MAGNETIC DIPOLE MOMENT (GAUSS-KM3)                 NEWMAG,308
C         COSLT0 - COSINE OF NORTH LATITUDE OF MAGNETIC DIPOLE MOMENT NEWMAG,309
C         SINLT0 - SINE   OF NORTH LATITUDE OF MAGNETIC DIPOLE MOMENT NEWMAG,310
C         PHI0   - EAST LONGITUDE OF MAGNETIC DIPOLE MOMENT (RADIANS) NEWMAG,311
C       CNSTNT COMMON                                                 NEWMAG,312
C         RECM   - EARTH RADIUS (CM)                                  NEWMAG,313
C         PI     - 3.1415926535898                                    NEWMAG,314
C                                                                     NEWMAG,315
C     OUTPUT PARAMETERS                                               NEWMAG,316
C       ALAT2  -  NORTH LATITUDE OF POINT 2 (RADIANS)                 NEWMAG,317
C       ALON2  -  EAST LONGITUDE OF POINT 2 (RADIANS)                 NEWMAG,318
C       S12    -  DISTANCE ALONG FIELD BETWEEN POINT 1 AND POINT 2 (IN NEWMAG,319
C                 UNITS OF THE EQUATORIAL VALUE OF THE TRACED LINE)   NEWMAG,320
C       BFB1   -  RATIO OF THE EQUATORIAL VALUE OF THE FIELD TO THAT AT NEWMAG,321
C                 POINT 1 FOR THE TRACED LINE                         NEWMAG,322
C                                                                     NEWMAG,323
      COMMON /MAGLNK/ MU0,COSLT0,SINLT0,PHI0                          NEWMAG,324
      COMMON/CNSTNT/ RECM,PI,HALFPI,FOURPI,GRAVZ(7)                   NEWMAG,325
C                                                                     NEWMAG,326
      REAL MU0                                                        NEWMAG,327
C                                                                     NEWMAG,328
      RE = 1.0E-05*RECM                                               NEWMAG,329
14    TWOPI = 2.*PI                                                   NEWMAG,330
C                                                                     NEWMAG,331
C  CALCULATE SINE AND COSINE OF ANGLE BETWEEN MAGNETIC DIPOLE MOMENT  NEWMAG,332
C  AND POINT 1                                                        NEWMAG,333
C                                                                     NEWMAG,334
```

CONJUG (Cont'd)

```
17          COSLT1 = COS(ALAT1)                                                  NEWMAG,335
20          SINLT1 = SIN(ALAT1)                                                  NEWMAG,336
25          DIFF = ALON1 - PHI0                                                  NEWMAG,337
33          COSZ1 = SINLT0*SINLT1 + COSLT0*COSLT1*COS(DIFF)                      NEWMAG,338
41          SINZ12 = 1. - COSZ1*COSZ1                                            NEWMAG,339
43          SINZ1 = SQRT(SINZ12)                                                 NEWMAG,340
      C                                                                          NEWMAG,341
      C  CALCULATE SINE AND COSINE OF ANGLE BETWEEN MAGNETIC DIPOLE MOMENT       NEWMAG,342
      C  AND POINT 2                                                             NEWMAG,343
      C                                                                          NEWMAG,344
45          SINZ22 = SINZ12*(RE + ALT2)/(RE + ALT1)                              NEWMAG,345
55          SINZ2 = SQRT(SINZ22)                                                 NEWMAG,346
57          COSZ2 = SQRT(1. - SINZ22)                                            NEWMAG,347
      C                                                                          NEWMAG,348
      C  DETERMINE SIGN OF COSZ2  -  IF POINT 2 IS IN THE SAME                   NEWMAG,349
      C  MAGNETIC HEMISHERE, THEN SIGN OF COSZ2 IS THE SAME AS THAT OF           NEWMAG,350
      C  COSZ1 (COSINE OF ANGLE BETWEEN MAGNETIC DIPOLE MOMENT AND POINT 1),     NEWMAG,351
      C  IF IN OPPOSITE MAGNETIC HEMISPHERE, THEN SIGN OF COSZ2 IS OPPOSITE      NEWMAG,352
      C  SIGN OF COSZ1                                                           NEWMAG,353
      C                                                                          NEWMAG,354
63          COSZ2 = SIGN(COSZ2,AJUG*COSZ1)                                       NEWMAG,355
      C                                                                          NEWMAG,356
      C  CALCULATE SINE AND COSINE OF ANGLE BETWEEN FIELD LINE AND LINE          NEWMAG,357
      C  JOINING MAGNETIC DIPOLE MOMENT WITH GEOGRAPHIC NORTH POLE               NEWMAG,358
      C                                                                          NEWMAG,359
72          SINPSI = COSLT1 * SIN(DIFF) / SINZ1                                  NEWMAG,360
102         COSPSI = (SINLT1 - COSZ1*SINLT0)/(SINZ1*COSLT0)                      NEWMAG,361
      C                                                                          NEWMAG,362
      C  CALCULATE NORTH LATITUDE OF POINT 2                                     NEWMAG,363
      C                                                                          NEWMAG,364
106         SINLT2 = COSZ2 * SINLT0 + SINZ2 * COSLT0 * COSPSI                    NEWMAG,365
112         ALAT2 = ASIN(SINLT2)                                                 NEWMAG,366
      C                                                                          NEWMAG,367
      C  CALCULATE EAST LONGITUDE OF POINT 2                                     NEWMAG,368
      C                                                                          NEWMAG,369
117         SINDIF = SINZ2 * SINPSI / COS(ALAT2)                                 NEWMAG,370
122         DIFF = ASIN(SINDIF)                                                  NEWMAG,371
124         COSSGN = COSZ2 - SINLT0*SINLT2                                       NEWMAG,372
127         IF(COSSGN .LT. 0.)DIFF = SIGN(PI,SINDIF) - DIFF                      NEWMAG,373
141         ALON2 = PHI0 + DIFF                                                  NEWMAG,374
143         IF(ALON2 .LT. 0.) ALON2 = ALON2 + TWOPI                              NEWMAG,375
147         ALON2 = AMOD(ALON2,TWOPI)                                            NEWMAG,376
      C                                                                          NEWMAG,377
      C  CALCULATE DIPOLE-FIELD PATH LENGTH BETWEEN POINT 1 AND POINT 2 (IN      NEWMAG,378
      C  UNITS OF THE EQUATORIAL RADIUS OF THE TRACED FIELD LINE)                NEWMAG,379
      C                                                                          NEWMAG,380
153         R3 = SQRT(3.)                                                        NEWMAG,381
155         R3MU1 = R3 * COSZ1                                                   NEWMAG,382
156         R3MU2 = R3 * COSZ2                                                   NEWMAG,383
160         R1PR12 = SQRT(1. + R3MU1 * R3MU1)                                    NEWMAG,384
164         R1PR22 = SQRT(1. + R3MU2 * R3MU2)                                    NEWMAG,385
171         S1E = ABS(R3MU1 * R1PR12 + ALOG(R3MU1 + R1PR12))                     NEWMAG,386
200         S2E = ABS(R3MU2 * R1PR22 + ALOG(R3MU2 + R1PR22))                     NEWMAG,387
215         S12 = ABS(S1E - AJUG * S2E) * R3/6.                                  NEWMAG,388
      C                                                                          NEWMAG,389
      C  CALCULATE RATIO OF EQUATORIAL VALUE OF THE FIELD TO THAT AT POINT 1     NEWMAG,390
      C  FOR THE TRACED FIELD LINE                                               NEWMAG,391
      C                                                                          NEWMAG,392
217         BEB1 = SINZ12**3/R1PR12                                              NEWMAG,393
      C                                                                          NEWMAG,394
223         RETURN                                                               NEWMAG,395
223         END                                                                  NEWMAG,396
```

MAGFIT

```
      SUBROUTINE MAGFIT(ALATF,ALONF,ALTF,TM)                                NEWMAG.397
C                                                                           NEWMAG.398
C  *  *  *  *                                                              NEWMAG.399
C                                                                           NEWMAG.400
C     THIS ROUTINE FITS A DIPOLE FIELD TO THE LOCAL MAGNETIC                NEWMAG.401
C     FIELD AT A SPECIFIED POINT P.  P IS GIVEN BY ALATF,ALONF,ALTF.        NEWMAG.402
C     THE MAGNETIC FIELD AT P IS FOUND FROM MODEL 5 OF STASSINOPOULOS       NEWMAG.403
C     MODELS.  MODEL 5 IS IGRF 10/68.  REFERENCE - STASSINOPOULOS, E.G.     NEWMAG.404
C     AND G.D. MEAD, ALLMAG, FIELD-LINE CALCULATION, NASA-GODDARD SPACE     NEWMAG.405
C     FLIGHT CENTER, NSSDC 72-12, FEBRUARY 1972.                            NEWMAG.406
C                                                                           NEWMAG.407
C  *  *  *  *                                                              NEWMAG.408
C                                                                           NEWMAG.409
C     INPUT PARAMETERS                                                      NEWMAG.410
C       ALATF  - GEOCENTRIC NORTH LATITUDE                                  NEWMAG.411
C                OF SPECIFIED POINT P (RADIANS)                             NEWMAG.412
C       ALONF  - GEOCENTRIC EAST LONGITUDE                                  NEWMAG.413
C                OF SPECIFIED POINT P (RADIANS)                             NEWMAG.414
C       ALTF   - ALTITUDE OF SPECIFIED POINT P (KM)                         NEWMAG.415
C       TM     - TIME FOR DESIRED FIELD (YEARS)                             NEWMAG.416
C                                                                           NEWMAG.417
C       CNSTNT COMMON                                                       NEWMAG.418
C                                                                           NEWMAG.419
C       HALFPI - PI/2                                                       NEWMAG.420
C       PI     - 3.1415926535898                                            NEWMAG.421
C       RECM   - EARTH RADIUS (CM)                                          NEWMAG.422
C                                                                           NEWMAG.423
C     OUTPUT PARAMETERS (TO MAGLNK COMMON)                                  NEWMAG.424
C       MU0    - MAGNETIC DIPOLE MOMENT (GAUSS-KM3)                         NEWMAG.425
C       COSLT0 - COSINE OF NORTH LATITUDE OF MAGNETIC DIPOLE MOMENT         NEWMAG.426
C       SINLT0 - SINE   OF NORTH LATITUDE OF MAGNETIC DIPOLE MOMENT         NEWMAG.427
C       PHI0   - EAST LONGITUDE OF MAGNETIC DIPOLE MOMENT (RADIANS)         NEWMAG.428
C                                                                           NEWMAG.429
      REAL LAMDA,LAMARG                                                     NEWMAG.430
      REAL MU0                                                              NEWMAG.431
C                                                                           NEWMAG.432
      COMMON /MAGLNK/ MU0,COSLT0,SINLT0,PHI0                                NEWMAG.433
      COMMON/CNSTNT/RECM,PI,HALFPI,FOURPI,GRAVZ,GZRE2,BOLTZK,GAM1,GM1I      NEWMAG.434
     1              ,PMNIT,PMOXY                                            NEWMAG.435
C                                                                           NEWMAG.436
      RE=RECM*1.E-5                                                         NEWMAG.437
 7    TWOPI=2.*PI                                                           NEWMAG.438
11    PIOV2=HALFPI                                                          NEWMAG.439
C                                                                           NEWMAG.440
C  SET UP INPUT FOR CALL TO EXACT AMBIENT MAGNETIC FIELD MODEL              NEWMAG.441
C                                                                           NEWMAG.442
13    RKM = RE + ALTF                                                       NEWMAG.443
14    COLAT = PIOV2 - ALATF                                                 NEWMAG.444
16    ST = SIN(COLAT)                                                       NEWMAG.445
20    CT = COS(COLAT)                                                       NEWMAG.446
22    SPH = SIN(ALONF)                                                      NEWMAG.447
27    CPH = COS(ALONF)                                                      NEWMAG.448
C                                                                           NEWMAG.449
C  CALCULATE MAGNETIC FIELD COMPONENTS AT POINT P                           NEWMAG.450
C  FROM STASSINOPOULOS MODEL, MODEL 5 (IGRF 10/68).                         NEWMAG.451
C                                                                           NEWMAG.452
```

MAGFIT (Cont'd)

```
 35        CALL ONEMGS(TM,RKM,ST,CT,SPH,CPH,BR,BTHETA,BPHI,B)                NEWMAG,453
      C                                                                      NEWMAG,454
      C  CALCULATE MAGNETIC DIPOLE MOMENT(GAUSS-KM3) FROM THE FIELD COMPONENTSNEWMAG,455
      C  BR (RADIAL), BTHETA (POSITIVE SOUTH), AND BPHI (POSITIVE EAST).     NEWMAG,456
      C                                                                      NEWMAG,457
 51        B2SQ = BTHETA*BTHETA + BPHI*BPHI                                  NEWMAG,458
 53        MUO = RKM**3*0.5*SQRT(BR*BR + 4.*B2SQ)                            NEWMAG,459
      C                                                                      NEWMAG,460
      C  CALCULATE THE SINE AND COSINE OF THE ANGLE ALPHA AT P WHICH IS THE  NEWMAG,461
      C  ANGLE BETWEEN THE MAGNETIC DIPOLE MOMENT AND GEOGRAPHIC NORTH POLE  NEWMAG,462
      C  AND DETERMINE THE PROPER SIGNS                                      NEWMAG,463
      C                                                                      NEWMAG,464
 63        ALPARG = BPHI/BTHETA                                              NEWMAG,465
 65        ALPHA = ATAN(ALPARG)                                              NEWMAG,466
 67        COSALP = ABS(COS(ALPHA))                                          NEWMAG,467
 73        SINALP = ABS(SIN(ALPHA))                                          NEWMAG,468
 77        IF(BTHETA .LT. 0.)COSALP = -COSALP                                NEWMAG,469
104        IF(BPHI .LT. 0.)SINALP = -SINALP                                  NEWMAG,470
      C                                                                      NEWMAG,471
      C  CALCULATE THE ANGLE CHI MEASURED AT EARTH CENTER WHICH              NEWMAG,472
      C  IS THE ANGLE BETWEEN THE MAGNETIC DIPOLE MOMENT AND THE SPECIFIED   NEWMAG,473
      C  POINT P                                                            NEWMAG,474
      C                                                                      NEWMAG,475
107        CHIARG = 2.*SQRT(B2SQ)/BR                                         NEWMAG,476
113        CHI = ATAN(CHIARG)                                                NEWMAG,477
115        IF(CHI .LT. 0.)CHI = PI + CHI                                     NEWMAG,478
123        COSCHI = COS(CHI)                                                 NEWMAG,479
125        SINCHI = SIN(CHI)                                                 NEWMAG,480
      C                                                                      NEWMAG,481
      C  CALCULATE SINE AND COSINE OF THE                                    NEWMAG,482
      C  NORTH LATITUDE OF THE MAGNETIC DIPOLE MOMENT                        NEWMAG,483
      C                                                                      NEWMAG,484
127        SINLTO = COSCHI*CT + SINCHI*ST*COSALP                             NEWMAG,485
133        COSLTO = SQRT(1. - SINLTO*SINLTO)                                 NEWMAG,486
      C                                                                      NEWMAG,487
      C  CALCULATE THE EAST LONGITUDE OF THE MAGNETIC DIPOLE MOMENT          NEWMAG,488
      C                                                                      NEWMAG,489
137        SINDEL = SINCHI*SINALP/COSLTO                                     NEWMAG,490
142        DEL = ASIN(SINDEL)                                                NEWMAG,491
144        COSDEL = COSCHI - SINLTO*CT                                       NEWMAG,492
147        IF(COSDEL .LT. 0.)DEL = SIGN(PI,SINDEL) - DEL                     NEWMAG,493
160        PHIO = ALONP - DEL                                                NEWMAG,494
162        IF(PHIO .LT. 0.) PHIO = PHIO + TWOPI                              NEWMAG,495
      C                                                                      NEWMAG,496
165        RETURN                                                            NEWMAG,497
166        END                                                               NEWMAG,498
```

ONEMG5

```
      SUBROUTINE ONEMG5(TM,RKM,ST,CT,SPH,CPH,BR,BTHETA,BPHI,B)          NEWMAG,499
C                                                                       NEWMAG,500
C  *  *  *  *                                                          NEWMAG,501
C                                                                       NEWMAG,502
C     THIS ROUTINE CALCULATES THE MAGNTIC FIELD VECTOR AT A SPECIFIED   NEWMAG,503
C     POINT USING MODEL 5 OF STASSINOPOULOS AND MEAD (NSSDC 72-12), THE NEWMAG,504
C     ROUTINE IS A MODIFIED VERSION OF ONEMAG FOR THE INTERNATIONAL     NEWMAG,505
C     GEOMAGNETIC REFERENCE FIELD (IGRF 1965.0).                        NEWMAG,506
C                                                                       NEWMAG,507
C     INPUT PARAMETERS                                                  NEWMAG,508
C       TM     - TIME IN YEARS FOR DESIRED FIELD                        NEWMAG,509
C       RKM    - GEOCENTRIC DISTANCE OF POINT (KM)                      NEWMAG,510
C       ST     - SINE OF GEOCENTRIC COLATITUDE OF POINT                 NEWMAG,511
C       CT     - COSINE OF GEOCENTRIC COLATITUDE OF POINT               NEWMAG,512
C       SPH    - SINE OF GEOCENTRIC LONGITUDE OF POINT (POSITIVE EAST)  NEWMAG,513
C       CPH    - COSINE OF GEOCENTRIC LONGITUDE OF POINT (POSITIVE EAST)NEWMAG,514
C                                                                       NEWMAG,515
C     OUTPUT PARAMETERS                                                 NEWMAG,516
C       BR     - RADIAL FIELD COMPONENT (GAUSS)                         NEWMAG,517
C       BTHETA - POSITIVE SOUTH FIELD COMPONENT (GAUSS)                 NEWMAG,518
C       BPHI   - POSITIVE EAST FIELD COMPONENT (GAUSS)                  NEWMAG,519
C       B      - TOTAL FIELD MAGNITUDE (GAUSS)                          NEWMAG,520
C                                                                       NEWMAG,521
      DIMENSION LG(9,9),LGT(9,9),G(9,9),GG(9,9),GGT(9,9),               NEWMAG,522
     1 SHMIT(9,9)                                                       NEWMAG,523
      DIMENSION CONST(9,9),FN(9),FM(9)                                  NEWMAG,524
      DIMENSION P(9,9),DP(9,9),SP(9),CP(9)                              NEWMAG,525
C                                                                       NEWMAG,526
      EQUIVALENCE (LG(1,1),GG(1,1)),(LGT(1,1),GGT(1,1))                 NEWMAG,527
C                                                                       NEWMAG,528
      DATA LG/1,-30339,-1654,1297,958,-223,47,71,10,5758,-2123,2994,    NEWMAG,529
     A -2036,805,357,60,-54,9,-2006,130,1567,1289,492,246,4,0,-5,-803,  NEWMAG,530
     B 242,-176,843,-392,-26,-229,12,-12,149,-280,8,-265,256,-161,3,-25,NEWMAG,531
     C -4,16,125,-123,-107,77,-51,-4,-9,7,-14,106,68,-32,-10,-13,-112,  NEWMAG,532
     D 13,-5,-57,-27,-8,9,23,-19,-17,-2,12,3,-13,5,-17,4,22,-3,-16,6/   NEWMAG,533
      DATA LGT/10,153,-244,2,-7,19,-1,-5,1,-23,87,3,-108,2,11,-3,-3,4,  NEWMAG,534
     E -118,-167,-16,7,-30,29,11,-7,6,42,7,-77,-38,-1,6,19,-5,0,-1,16,  NEWMAG,535
     F 29,-42,-21,0,-4,3,0,23,17,-24,8,-3,13,-4,0,-1,-9,-4,20,-11,1,9,  NEWMAG,536
     G -2,-2,3,-11,3,4,2,4,2,3,-6,-3,1,-2,-3,-2,-3,-4,-3,-3,-5/         NEWMAG,537
      DATA SHMIT(1,1)/0./,TMOLD/0./,TZERO/1965./,NMAX/9/                NEWMAG,538
      DATA P(1,1),CP(1),DP(1,1),SP(1) / 2*1.,2*0. /                     NEWMAG,539
C                                                                       NEWMAG,540
      IF(SHMIT(1,1).EQ.-1.)   GO TO 8                                   NEWMAG,541
C                                                                       NEWMAG,542
C  *****  INITIALIZE * ONCE ONLY, FIRST TIME SUBROUTINE IS CALLED       NEWMAG,543
C                                                                       NEWMAG,544
16    SHMIT(1,1)=-1.                                                    NEWMAG,545
16    DO 18 N=1,9                                                       NEWMAG,546
20    FN(N)=N                                                           NEWMAG,547
22    DO 18 M=1,9                                                       NEWMAG,548
37    FM(M)=M-1                                                         NEWMAG,549
41  18 CONST(N,M) = FLOAT((N-2)**2-(M-1)**2) / ((2*N-3)*(2*N-5))        NEWMAG,550
54    DO 2 N=2,9                                                        NEWMAG,551
57    SHMIT(N,1) = (2*N-3) * SHMIT(N-1,1) / (N-1)                       NEWMAG,552
66    JJ=2                                                              NEWMAG,553
70    DO 2 M=2,N                                                        NEWMAG,554
```

ONEMG5 (Cont'd)

```
 71          SHMIT(N,M) = SHMIT(N,M-1) * SQRT(FLOAT((N-M+1)*JJ)/(N+M-2))      NEWMAG,555
107          SHMIT(M-1,N)=SHMIT(N,M)                                          NEWMAG,556
117        2 JJ = 1                                                           NEWMAG,557
124          F1 = LG(1,1)                                                     NEWMAG,558
125          F2 = LGT(1,1)                                                    NEWMAG,559
127          DO 7 N=1,NMAX                                                    NEWMAG,560
130          DO 7 M=1,NMAX                                                    NEWMAG,561
140          GG(N,M) = LG(N,M)*SHMIT(N,M)/F1                                  NEWMAG,562
143        7 GGT(N,M) = LGT(N,M)*SHMIT(N,M)/F2                                NEWMAG,563
155        8 IF(TM.EQ.TMOLD) GO TO 11                                         NEWMAG,564
157          TMOLD=TM                                                         NEWMAG,565
160          T = TM - TZERO                                                   NEWMAG,566
161          DO 10 N=1,NMAX                                                   NEWMAG,567
163          DO 10 M=1,NMAX                                                   NEWMAG,568
173       10 G(N,M) = GG(N,M) + T*GGT(N,M)                                    NEWMAG,569
          C                                                                   NEWMAG,570
          C  *****  CALCULATION USUALLY BEGINS HERE                          NEWMAG,571
          C                                                                   NEWMAG,572
204       11 SP(2)=SPH                                                        NEWMAG,573
205          CP(2)=CPH                                                        NEWMAG,574
206          DO 12 M=3,NMAX                                                   NEWMAG,575
215          SP(M)=SP(2)*CP(M-1)+CP(2)*SP(M-1)                                NEWMAG,576
220       12 CP(M)=CP(2)*CP(M-1)-SP(2)*SP(M-1)                                NEWMAG,577
227          AOR=6371.2/RKM                                                   NEWMAG,578
230          AR=AOR**2                                                        NEWMAG,579
231          BR=0.0                                                           NEWMAG,580
232          BT=0.0                                                           NEWMAG,581
233          BP=0.0                                                           NEWMAG,582
234          DO 21 N=2,NMAX                                                   NEWMAG,583
242          P(N-1,N)=0.                                                      NEWMAG,584
243       21 DP(N-1,N)=0.                                                     NEWMAG,585
245          DO 17 N=2,NMAX                                                   NEWMAG,586
252          AR=AOR*AR                                                        NEWMAG,587
253          DO 17 M=1,N                                                      NEWMAG,588
255          IF(M.EQ.N) GO TO 13                                              NEWMAG,589
256          IF(N.EQ.2) GO TO 19                                              NEWMAG,590
262          P(N,M)=CT*P(N-1,M)-CONST(N,M)*P(N-2,M)                           NEWMAG,591
265          DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)-CONST(N,M)*DP(N-2,M)            NEWMAG,592
272          GO TO 14                                                         NEWMAG,593
301       19 P(N,M)=CT                                                        NEWMAG,594
302          DP(N,M)=-ST                                                      NEWMAG,595
304          GO TO 14                                                         NEWMAG,596
307       13 P(N,N)=ST*P(N-1,N-1)                                             NEWMAG,597
311          DP(N,N)=ST*DP(N-1,N-1)+CT*P(N-1,N-1)                             NEWMAG,598
317       14 PAR = P(N,M)*AR                                                  NEWMAG,599
323          IF(M.EQ.1) GO TO 15                                              NEWMAG,600
332          TEMP=G(N,M)*CP(M)+G(M-1,N)*SP(M)                                 NEWMAG,601
335          BP=BP-(G(N,M)*SP(M)-G(M-1,N)*CP(M))*FM(M)*PAR                    NEWMAG,602
342          GO TO 16                                                         NEWMAG,603
346       15 TEMP = G(N,M)                                                    NEWMAG,604
352       16 BR=BR-TEMP*FN(N)*PAR                                             NEWMAG,605
357       17 BT=BT+TEMP*DP(N,M)*AR                                            NEWMAG,606
371          BPHI = BP/ST/100000.                                             NEWMAG,607
373          BR = BR/100000.                                                  NEWMAG,608
374          BTHETA = BT/100000.                                              NEWMAG,609
376          B = SQRT(BR*BR + BTHETA*BTHETA + BPHI*BPHI)                      NEWMAG,610
404          RETURN                                                           NEWMAG,611
405          END                                                              NEWMAG,612
```

```
$START
&LATFI  =  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.3E+02,  0.3E+02,  0.3E+02,  0.3E+02,  0.3E+02,  0.3E+02,  0.6E+02,
           0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  -0.3E+02,  -0.3E+02,  -0.3E+02,  -0.3E+02,  -0.3E+02,  -0.3E+02,
          -0.6E+02,  -0.6E+02,  -0.6E+02,  -0.6E+02,  -0.6E+02,  -0.6E+02,  -0.85E+02,  -0.85E+02,  -0.85E+02,  -0.85E+02,
          -0.85E+02,  -0.85E+02,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
&LONFI  =  -0.6E+02,  0.0,  0.6E+02,  0.12E+03,  0.18E+03,  0.24E+03,  -0.6E+02,  0.0,  0.6E+02,  0.12E+03,  0.18E+03,
           0.24E+03,  -0.6E+02,  0.0,  0.6E+02,  0.12E+03,  0.18E+03,  0.24E+03,  -0.6E+02,  0.0,  0.6E+02,  0.12E+03,
           0.18E+03,  0.24E+03,  -0.6E+02,  0.0,  0.6E+02,  0.12E+03,  0.18E+03,  0.24E+03,  -0.6E+02,  0.0,  0.6E+02,
           0.12E+03,  0.18E+03,  0.24E+03,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
&LTFT   =  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,
           0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,
           0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,  0.2E+03,
           0.2E+03,  0.2E+03,  0.2E+03,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
NFIT    =  36,
TM      =  0.1975E+04,
RLATS   =  0.5E+01,  0.5E+01,  0.5E+01,  0.0,  0.0,  0.0,  -0.5E+01,  -0.5E+01,  -0.5E+01,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
           I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
RLONS   =  -0.1E+02,  0.0,  0.1E+02,  -0.1E+02,  0.0,  0.1E+02,  -0.1E+02,  0.0,  0.1E+02,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
           I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
RALTS   =  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
           I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
NRS     =  9,
RCONS   =  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  0.6E+02,  I,  I,  I,  I,  I,  I,
           I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
AJUGS   =  0.1E+01,  0.1E+01,  0.1E+01,  0.1E+01,  0.1E+01,  0.1E+01,  0.1E+01,  0.1E+01,  0.1E+01,  I,  I,  I,  I,  I,  I,
           I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,  I,
IOPT    =  3,
$END
```

LOCATION OF POINT THAT IS FITTED

LATITUDE = 0.00 (DEG)
LONGITUDE = -60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.496569E+10 GAUSS KM**3
COSLTO = 2.540602E-01
SINLTO = -9.671884E-01
PHIO = 1.440367E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
5.00	-70.00	200.00	.300	33.00	-7.08	60.00	1.00	6.790	289.776	.315	-4.818
5.00	-60.00	200.00	.295	30.75	-9.28	60.00	1.00	6.927	299.683	.304	-2.959
5.00	-50.00	200.00	.289	27.85	-11.17	60.00	1.00	7.128	309.577	.289	-.040
0.00	-70.00	200.00	.284	24.83	-6.91	60.00	1.00	2.414	289.707	.290	-2.075
0.00	-60.00	200.00	.280	22.38	-9.08	60.00	1.00	2.646	299.577	.280	-.000
0.00	-50.00	200.00	.276	19.22	-10.96	60.00	1.00	3.000	309.419	.268	2.830
-5.00	-70.00	200.00	.272	15.82	-6.80	60.00	1.00	-1.468	289.579	.269	1.327
-5.00	-60.00	200.00	.270	13.21	-8.95	60.00	1.00	-1.021	299.373	.260	3.899
-5.00	-50.00	200.00	.268	9.88	-10.83	60.00	1.00	-.312	309.104	.251	6.710

LOCATION OF POINT THAT IS FITTED

LATITUDE = 0.00 (DEG)
LONGITUDE = 0.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.493603E+10 GAUSS KM**3
COSLTO = 2.687086E-01
SINLTO = -9.632215E-01
PHIO = 7.187107E-01 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
5.00	-10.00	200.00	.267	-9.55	-12.13	60.00	1.00	.251	351.019	.275	-2.968
5.00	0.00	200.00	.270	-13.32	-10.26	60.00	1.00	1.056	.714	.285	-5.126
5.00	10.00	200.00	.273	-16.34	-8.08	60.00	1.00	1.562	10.488	.294	-7.379
0.00	-10.00	200.00	.276	-18.87	-12.26	60.00	1.00	-3.032	350.660	.270	2.240
0.00	0.00	200.00	.280	-22.44	-10.41	60.00	1.00	-2.628	.483	.280	.000
0.00	10.00	200.00	.285	-25.29	-8.22	60.00	1.00	-2.364	10.342	.291	-2.203
-5.00	-10.00	200.00	.289	-27.09	-12.49	60.00	1.00	-7.146	350.479	.266	8.511
-5.00	0.00	200.00	.295	-30.78	-10.64	60.00	1.00	-6.917	.363	.278	6.070
-5.00	10.00	200.00	.301	-33.39	-8.42	60.00	1.00	-6.760	10.262	.290	3.816

LOCATION OF POINT THAT IS FITTED

LATITUDE = 0.00 (DEG)
LONGITUDE = 60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 9.069742E+10 GAUSS KM**3
COSLTO = 1.988464E-01
SINLTO = -9.800307E-01
PHIO = 1.861959E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
5.00	50.00	200.00	.323	-9.04	-6.37	60.00	1.00	.037	50.553	.327	-1.16
5.00	60.00	200.00	.325	-10.90	-4.62	60.00	1.00	.490	60.364	.338	-4.07
5.00	70.00	200.00	.326	-12.15	-2.73	60.00	1.00	.757	70.202	.352	-7.47
0.00	50.00	200.00	.333	-18.53	-6.43	60.00	1.00	-3.129	50.353	.322	3.305
0.00	60.00	200.00	.336	-20.31	-4.67	60.00	1.00	-2.908	60.238	.336	-.040
0.00	70.00	200.00	.338	-21.49	-2.76	60.00	1.00	-2.775	70.134	.353	-4.341
-5.00	50.00	200.00	.349	-27.32	-6.55	60.00	1.00	-7.198	50.254	.321	8.748
-5.00	60.00	200.00	.353	-28.96	-4.77	60.00	1.00	-7.075	60.174	.337	4.654
-5.00	70.00	200.00	.355	-30.05	-2.82	60.00	1.00	-7.000	70.099	.359	-.937

LOCATION OF POINT THAT IS FITTED

LATITUDE = 0.00 (DEG)
LONGITUDE = 120.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 1.018630E+11 GAUSS KM**3
COSLTO = 1.663079E-01
SINLTO = -9.860739E-01
PHIO = 1.879308E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
5.00	110.00	200.00	.363	-9.07	.39	60.00	1.00	.017	109.966	.370	-1.83
5.00	120.00	200.00	.363	-8.66	2.04	60.00	1.00	-.093	119.819	.363	-.047
5.00	130.00	200.00	.362	-7.68	3.63	60.00	1.00	-.363	129.660	.354	2.364
0.00	110.00	200.00	.374	-18.65	.39	60.00	1.00	-3.136	109.979	.380	-1.410
0.00	120.00	200.00	.374	-18.23	2.06	60.00	1.00	-3.189	119.885	.374	-.000
0.00	130.00	200.00	.372	-17.30	3.67	60.00	1.00	-3.319	129.787	.366	1.765
-5.00	110.00	200.00	.392	-27.46	.40	60.00	1.00	-7.201	109.985	.397	-1.134
-5.00	120.00	200.00	.391	-27.09	2.10	60.00	1.00	-7.230	119.918	.392	-.144
-5.00	130.00	200.00	.389	-26.23	3.73	60.00	1.00	-7.300	129.849	.385	1.059

LOCATION OF POINT THAT IS FITTED

LATITUDE = 0.00 (DEG)
LONGITUDE = 180.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.077834E+10 GAUSS KM**3
COSLTO = 1.885935E-01
SINLTO = -9.820552E-01
PHIO = 1.811749E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
5.00	170.00	200.00	.317	1.12	9.94	60.00	1.00	12.735	171.385	.314	.847
5.00	180.00	200.00	.318	4.66	10.56	60.00	1.00	11.267	181.189	.309	2.921
5.00	190.00	200.00	.319	8.34	10.88	60.00	1.00	10.090	190.992	.305	4.682
0.00	170.00	200.00	.320	-8.68	9.97	60.00	1.00	-5.012	169.117	.326	-2.049
0.00	180.00	200.00	.318	-5.15	10.56	60.00	1.00	-6.095	178.859	.318	-.000
0.00	190.00	200.00	.317	-1.44	10.85	60.00	1.00	-7.570	188.541	.311	1.933
-5.00	170.00	200.00	.329	-18.12	10.07	60.00	1.00	-8.157	169.434	.344	-4.473
-5.00	180.00	200.00	.325	-14.74	10.64	60.00	1.00	-8.677	179.301	.333	-2.467
-5.00	190.00	200.00	.321	-11.15	10.90	60.00	1.00	-9.387	189.145	.323	-.434

LOCATION OF POINT THAT IS FITTED

LATITUDE = 0.00 (DEG)
LONGITUDE = 240.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.277183E+10 GAUSS KM**3
COSLTO = 1.777932E-01
SINLTO = -9.840679E-01
PHIO = 2.114454E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
5.00	230.00	200.00	.301	16.12	9.79	60.00	1.00	8.457	230.603	.305	-1.158
5.00	240.00	200.00	.305	19.17	9.09	60.00	1.00	8.024	240.489	.308	-.896
5.00	250.00	200.00	.309	21.88	8.12	60.00	1.00	7.706	250.389	.312	-.903
0.00	230.00	200.00	.294	6.56	9.70	60.00	1.00	5.639	230.967	.296	-.840
0.00	240.00	200.00	.295	9.77	8.99	60.00	1.00	4.742	240.752	.295	.000
0.00	250.00	200.00	.298	12.65	8.01	60.00	1.00	4.101	250.578	.296	.628
-5.00	230.00	200.00	.293	-3.27	9.69	60.00	1.00	-11.816	228.813	.294	-.512
-5.00	240.00	200.00	.292	-.03	8.96	60.00	1.00	-13.274	238.664	.290	.869
-5.00	250.00	200.00	.292	2.90	7.96	60.00	1.00	1.999	250.977	.286	2.164

LOCATION OF POINT THAT IS FITTED

LATITUDE = 30.00 (DEG)
LONGITUDE = -60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.278113E+10 GAUSS KM**3
COSLTO = 2.836154E-01
SINLTO = -9.589381E-01
PHIO = 1.284178E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
35.00	-70.00	200.00	.474	65.36	-14.43	60.00	1.00	35.543	289.828	.483	-1.954
35.00	-60.00	200.00	.463	63.63	-16.97	60.00	1.00	35.579	299.783	.463	.032
35.00	-50.00	200.00	.451	61.57	-18.76	60.00	1.00	35.625	309.739	.439	2.742
30.00	-70.00	200.00	.450	61.48	-13.23	60.00	1.00	30.645	289.824	.459	-1.880
30.00	-60.00	200.00	.440	59.61	-15.66	60.00	1.00	30.688	299.776	.440	.000
30.00	-50.00	200.00	.427	57.36	-17.44	60.00	1.00	30.744	309.728	.416	2.763
25.00	-70.00	200.00	.426	57.14	-12.29	60.00	1.00	25.768	289.814	.432	-1.366
25.00	-60.00	200.00	.415	55.09	-14.64	60.00	1.00	25.820	299.762	.414	.362
25.00	-50.00	200.00	.403	52.61	-16.40	60.00	1.00	25.889	309.709	.390	3.137

LOCATION OF POINT THAT IS FITTED

LATITUDE = 30.00 (DEG)
LONGITUDE = 0.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.378920E+10 GAUSS KM**3
COSLTO = 1.234338E-01
SINLTO = -9.923528E-01
PHIO = 6.754146E-01 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
35.00	-10.00	200.00	.392	49.29	-6.16	60.00	1.00	36.034	349.862	.383	2.416
35.00	0.00	200.00	.388	48.37	-5.08	60.00	1.00	36.069	359.882	.384	.964
35.00	10.00	200.00	.385	47.62	-3.88	60.00	1.00	36.099	9.908	.389	-1.133
30.00	-10.00	200.00	.367	43.25	-5.88	60.00	1.00	31.268	349.847	.361	1.810
30.00	0.00	200.00	.363	42.19	-4.86	60.00	1.00	31.317	359.869	.363	-.000
30.00	10.00	200.00	.360	41.32	-3.71	60.00	1.00	31.357	9.897	.369	-2.451
25.00	-10.00	200.00	.345	36.37	-5.67	60.00	1.00	26.598	349.822	.339	1.782
25.00	0.00	200.00	.341	35.15	-4.69	60.00	1.00	26.669	359.847	.342	-.361
25.00	10.00	200.00	.338	34.16	-3.59	60.00	1.00	26.729	9.879	.349	-3.126

LOCATION OF POINT THAT IS FITTED

LATITUDE = 30.00 (DEG)
LONGITUDE = 60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 9.408114E+10 GAUSS KM**3
COSLTO = 6.029442E-02
SINLTO = -9.981806E-01
PHIO = 7.320645E-01 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
35.00	50.00	200.00	.448	50.87	.57	60.00	1.00	35.985	50.012	.428	4.681
35.00	60.00	200.00	.449	51.02	1.26	60.00	1.00	35.980	60.027	.441	1.739
35.00	70.00	200.00	.450	51.26	1.91	60.00	1.00	35.971	70.040	.454	-.804
30.00	50.00	200.00	.420	45.01	.54	60.00	1.00	31.202	50.013	.409	2.720
30.00	60.00	200.00	.421	45.18	1.20	60.00	1.00	31.195	60.029	.421	-.000
30.00	70.00	200.00	.422	45.46	1.82	60.00	1.00	31.184	70.044	.432	-2.204
25.00	50.00	200.00	.394	38.34	.52	60.00	1.00	26.503	50.015	.389	1.328
25.00	60.00	200.00	.394	38.53	1.15	60.00	1.00	26.493	60.034	.399	-1.242
25.00	70.00	200.00	.396	38.85	1.75	60.00	1.00	26.476	70.050	.409	-3.222

LOCATION OF POINT THAT IS FITTED

LATITUDE = 30.00 (DEG)
LONGITUDE = 120.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 9.441025E+10 GAUSS KM**3
COSLTO = 9.915556E-02
SINLTO = -9.950719E-01
PHIO = 2.661015E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
35.00	110.00	200.00	.464	49.92	-4.47	60.00	1.00	36.015	109.902	.472	-1.669
35.00	120.00	200.00	.460	49.27	-3.53	60.00	1.00	36.039	119.921	.459	.365
35.00	130.00	200.00	.458	48.78	-2.50	60.00	1.00	36.058	129.943	.438	4.419
30.00	110.00	200.00	.435	43.95	-4.26	60.00	1.00	31.242	109.892	.444	-2.077
30.00	120.00	200.00	.431	43.21	-3.37	60.00	1.00	31.275	119.912	.431	-.000
30.00	130.00	200.00	.429	42.64	-2.39	60.00	1.00	31.300	129.936	.412	4.053
25.00	110.00	200.00	.408	37.15	-4.11	60.00	1.00	26.561	109.875	.417	-2.289
25.00	120.00	200.00	.405	36.30	-3.25	60.00	1.00	26.608	119.898	.406	-.250
25.00	130.00	200.00	.402	35.64	-2.31	60.00	1.00	26.645	129.926	.388	3.630

LOCATION OF POINT THAT IS FITTED

LATITUDE = 30.00 (DEG)
LONGITUDE = 180.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.702429E+15 GAUSS KM**3
COSLTO = 1.593202E-01
SINLTO = -9.872273E-01
PHIO = 2.951491E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE R	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGNF R	PERCENT
35.00	170.00	200.00	.350	38.10	8.32	60.00	1.00	34.072	170.194	.363	-1.040
35.00	180.00	200.00	.365	40.55	9.43	60.00	1.00	34.017	180.209	.362	.032
35.00	190.00	200.00	.372	41.11	10.30	60.00	1.00	35.961	190.214	.368	.070
30.00	170.00	200.00	.337	41.92	7.96	60.00	1.00	31.320	170.214	.343	-1.815
30.00	180.00	200.00	.342	43.59	9.00	60.00	1.00	31.265	180.231	.342	-.000
30.00	190.00	200.00	.349	45.39	9.81	60.00	1.00	31.170	190.236	.349	.071
25.00	170.00	200.00	.314	36.89	7.69	60.00	1.00	26.674	170.253	.327	-3.301
25.00	180.00	200.00	.321	38.81	8.68	60.00	1.00	26.564	180.267	.327	-1.965
25.00	190.00	200.00	.327	38.86	9.45	60.00	1.00	26.457	190.270	.332	-1.490

LOCATION OF POINT THAT IS FITTED

LATITUDE = 30.00 (DEG)
LONGITUDE = 230.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.555126E+15 GAUSS KM**3
COSLTO = 2.174549E-01
SINLTO = -9.760708E-01
PHIO = 2.883531E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE R	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGNF R	PERCENT
35.00	230.00	200.00	.444	57.45	15.07	60.00	1.00	35.739	230.245	.437	1.595
35.00	240.00	200.00	.455	59.75	14.26	60.00	1.00	35.689	240.214	.457	-.511
35.00	250.00	200.00	.465	61.80	13.94	60.00	1.00	35.648	250.183	.475	-2.221
30.00	230.00	200.00	.419	55.11	15.15	60.00	1.00	30.883	230.260	.411	1.920
30.00	240.00	200.00	.430	55.20	13.33	60.00	1.00	30.822	240.227	.430	.000
30.00	250.00	200.00	.440	57.04	12.03	60.00	1.00	30.772	250.191	.447	-1.671
25.00	230.00	200.00	.391	47.73	13.43	60.00	1.00	24.067	230.284	.385	2.278
25.00	240.00	200.00	.404	50.08	12.49	60.00	1.00	25.988	240.244	.401	.713
25.00	250.00	200.00	.414	52.13	11.52	60.00	1.00	24.924	250.204	.417	-.775

LOCATION OF POINT THAT IS FITTED

LATITUDE = 60.00 (DEG)
LONGITUDE = -60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.7328?8E+10 GAUSS KM**3
COSLTO = 3.09A771E-01
SINLTO = +9.50A818E-01
PHIO = 1.3592?0E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
65.00	-70.00	200.00	.535	83.18	-45.09	60.00	1.00	65.103	289.?53	.533	.420
65.00	-60.00	200.00	.529	81.58	-47.00	60.00	1.00	65.124	299.684	.521	1.659
65.00	-50.00	200.00	.522	79.91	-48.80	60.00	1.00	65.149	309.A21	.508	2.926
60.00	-70.00	200.00	.527	81.13	-33.55	60.00	1.00	60.159	289.787	.536	-1.510
60.00	-60.00	200.00	.521	79.56	-34.91	60.00	1.00	60.181	299.727	.521	-.000
60.00	-50.00	200.00	.513	77.85	-36.19	60.00	1.00	60.207	309.671	.505	1.604
55.00	-70.00	200.00	.517	78.76	-29.48	60.00	1.00	55.218	289.809	.535	-3.308
55.00	-60.00	200.00	.510	77.92	-30.18	60.00	1.00	55.240	299.755	.518	-1.590
55.00	-50.00	200.00	.501	75.68	-32.10	60.00	1.00	55.269	309.704	.499	.308

LOCATION OF POINT THAT IS FITTED

LATITUDE = 60.00 (DEG)
LONGITUDE = 0.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.?19371E+10 GAUSS KM**3
COSLTO = 8.?95076E-02
SINLTO = +9.9A8699E-01
PHIO = 1.213036E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
65.00	-10.00	200.00	.477	76.13	-10.74	60.00	1.00	65.297	349.A65	.472	1.208
65.00	0.00	200.00	.475	75.68	-9.96	60.00	1.00	65.308	359.A70	.470	1.117
65.00	10.00	200.00	.473	75.27	-9.24	60.00	1.00	65.318	9.A86	.471	.405
60.00	-10.00	200.00	.462	73.15	-9.17	60.00	1.00	60.346	349.A80	.461	.114
60.00	0.00	200.00	.459	72.66	-8.54	60.00	1.00	60.378	359.A85	.459	-.000
60.00	10.00	200.00	.457	72.21	-7.70	60.00	1.00	60.389	9.A93	.460	-.805
55.00	-10.00	200.00	.444	69.93	-8.04	60.00	1.00	55.443	349.A90	.450	-1.259
55.00	0.00	200.00	.441	69.40	-7.52	60.00	1.00	55.456	359.A94	.448	-1.468
55.00	10.00	200.00	.439	68.91	-6.80	60.00	1.00	55.469	9.901	.449	-2.397

LOCATION OF POINT THAT IS FITTED

LATITUDE = 60.00 (DEG)
LONGITUDE = 60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.943127E+10 GAUSS KM**3
COSLTO = 1.218892E-01
SINLTO = -9.925437E-01
PHIO = 5.238498E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
65.00	50.00	200.00	.522	76.91	16.64	60.00	1.00	65.273	50.195	.503	3.749
65.00	60.00	200.00	.526	77.63	16.74	60.00	1.00	65.257	60.185	.516	1.829
65.00	70.00	200.00	.529	78.31	16.29	60.00	1.00	65.243	70.170	.530	-.080
60.00	50.00	200.00	.506	74.07	14.08	60.00	1.00	60.339	50.172	.496	2.150
60.00	60.00	200.00	.511	74.81	14.03	60.00	1.00	60.323	60.163	.511	.000
60.00	70.00	200.00	.515	75.52	13.52	60.00	1.00	60.308	70.149	.526	-2.169
55.00	50.00	200.00	.488	70.98	12.26	60.00	1.00	55.413	50.158	.480	.434
55.00	60.00	200.00	.493	71.77	12.14	60.00	1.00	55.394	60.149	.502	-1.794
55.00	70.00	200.00	.498	72.53	11.61	60.00	1.00	55.378	70.137	.519	-4.072

LOCATION OF POINT THAT IS FITTED

LATITUDE = 60.00 (DEG)
LONGITUDE = 120.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.078807E+10 GAUSS KM**3
COSLTO = 1.086381E-01
SINLTO = -9.940510E-01
PHIO = 6.113345E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
65.00	110.00	200.00	.569	79.15	-11.47	60.00	1.00	65.230	109.888	.557	2.085
65.00	120.00	200.00	.567	78.65	-12.94	60.00	1.00	65.240	119.868	.553	2.378
65.00	130.00	200.00	.564	78.10	-13.87	60.00	1.00	65.251	129.852	.545	3.378
60.00	110.00	200.00	.554	76.36	-9.38	60.00	1.00	60.294	109.902	.557	-.598
60.00	120.00	200.00	.551	75.85	-10.67	60.00	1.00	60.304	119.884	.551	.000
60.00	130.00	200.00	.548	75.27	-11.54	60.00	1.00	60.316	129.870	.540	1.521
55.00	110.00	200.00	.536	73.38	-7.98	60.00	1.00	55.362	109.911	.552	-2.746
55.00	120.00	200.00	.533	72.84	-9.14	60.00	1.00	55.373	119.894	.543	-1.847
55.00	130.00	200.00	.529	72.24	-9.94	60.00	1.00	55.387	129.881	.529	.191

LOCATION OF POINT THAT IS FITTED

LATITUDE = 60.00 (DEG)
LONGITUDE = 180.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.958228E+10 GAUSS KM**3
COSLTO = 1.229075E-01
SINLTO = -9.924876E-01
PHIO = 2.533698E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
65.00	170.00	200.00	.501	72.95	5.65	60.00	1.00	65.374	170.089	.506	-1.006
65.00	180.00	200.00	.503	73.27	7.80	60.00	1.00	65.365	180.120	.503	-.024
65.00	190.00	200.00	.505	73.67	9.84	60.00	1.00	65.354	190.147	.504	.236
60.00	170.00	200.00	.482	69.70	4.96	60.00	1.00	60.491	170.079	.487	-1.147
60.00	180.00	200.00	.484	70.05	6.84	60.00	1.00	60.441	180.107	.484	-.990
60.00	190.00	200.00	.486	70.50	8.59	60.00	1.00	60.429	190.131	.486	.109
55.00	170.00	200.00	.460	66.15	4.45	60.00	1.00	55.539	170.078	.464	-.844
55.00	180.00	200.00	.463	66.55	6.13	60.00	1.00	55.528	180.100	.461	.423
55.00	190.00	200.00	.466	67.05	7.68	60.00	1.00	55.513	190.122	.464	.333

LOCATION OF POINT THAT IS FITTED

LATITUDE = 60.00 (DEG)
LONGITUDE = 240.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.050872E+10 GAUSS KM**3
COSLTO = 2.675581E-01
SINLTO = -9.635417E-01
PHIO = 1.758412E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
65.00	230.00	200.00	.545	80.18	39.22	60.00	1.00	65.164	230.320	.535	1.978
65.00	240.00	200.00	.551	81.60	37.98	60.00	1.00	65.143	240.265	.542	1.574
65.00	250.00	200.00	.556	82.93	36.47	60.00	1.00	65.125	250.205	.548	1.441
60.00	230.00	200.00	.534	77.92	31.71	60.00	1.00	60.223	230.278	.530	.878
60.00	240.00	200.00	.541	79.35	29.66	60.00	1.00	60.200	240.230	.541	-.000
60.00	250.00	200.00	.547	80.62	25.77	60.00	1.00	60.182	250.177	.550	-.525
55.00	230.00	200.00	.521	75.38	26.57	60.00	1.00	55.286	230.251	.520	.178
55.00	240.00	200.00	.529	76.83	24.28	60.00	1.00	55.261	240.207	.535	-1.159
55.00	250.00	200.00	.535	78.09	20.53	60.00	1.00	55.242	250.159	.547	-2.137

LOCATION OF POINT THAT IS FITTED

LATITUDE = -50.00 (DEG)
LONGITUDE = -60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 5.834788F+10 GAUSS KM**3
COSLTO = 2.441004F-01
SINLTO = -9.698952F-01
PHIO = 1.958266F+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGNF B	PERCENT
-25.00	-70.00	200.00	.215	-18.85	.28	60.00	1.00	-28.105	289.983	.234	-8.185
-25.00	-60.00	200.00	.215	-19.16	-2.39	60.00	1.00	-28.061	300.145	.223	-3.595
-25.00	-50.00	200.00	.216	-20.23	-5.00	60.00	1.00	-27.916	310.289	.219	-1.364
-30.00	-70.00	200.00	.222	-27.47	.29	60.00	1.00	-32.184	289.987	.238	-5.398
-30.00	-60.00	200.00	.225	-27.94	-2.44	60.00	1.00	-32.160	300.108	.225	-.000
-30.00	-50.00	200.00	.227	-28.89	-5.10	60.00	1.00	-32.080	310.219	.221	2.082
-35.00	-70.00	200.00	.239	-35.59	.30	60.00	1.00	-36.650	289.989	.247	-3.414
-35.00	-60.00	200.00	.239	-35.83	-2.50	60.00	1.00	-36.635	300.089	.233	2.628
-35.00	-50.00	200.00	.241	-36.44	-5.25	60.00	1.00	-36.585	310.181	.227	5.950

LOCATION OF POINT THAT IS FITTED

LATITUDE = -30.00 (DEG)
LONGITUDE = 0.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 6.883398F+10 GAUSS KM**3
COSLTO = 3.939876F-01
SINLTO = -9.191158E-01
PHIO = 9.591103F-01 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGNF B	PERCENT
-25.00	-10.00	200.00	.236	-52.04	-25.08	60.00	1.00	-25.856	350.446	.254	-7.008
-25.00	0.00	200.00	.247	-55.86	-23.63	60.00	1.00	-25.755	.367	.265	-6.732
-25.00	10.00	200.00	.258	-59.10	-21.27	60.00	1.00	-25.679	10.294	.275	-6.202
-30.00	-10.00	200.00	.249	-58.59	-26.61	60.00	1.00	-30.717	350.418	.251	-.736
-30.00	0.00	200.00	.261	-60.08	-25.28	60.00	1.00	-30.635	.349	.261	.000
-30.00	10.00	200.00	.271	-63.04	-22.98	60.00	1.00	-30.572	10.282	.269	.898
-35.00	-10.00	200.00	.263	-60.61	-28.51	60.00	1.00	-35.603	350.403	.251	4.587
-35.00	0.00	200.00	.274	-63.79	-27.37	60.00	1.00	-35.514	.340	.259	5.861
-35.00	10.00	200.00	.284	-66.56	-25.15	60.00	1.00	-35.480	10.277	.265	7.112

LOCATION OF POINT THAT IS FITTED

LATITUDE = -30.00 (DEG)
LONGITUDE = 60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 6.639748E+10 GAUSS KM**3
COSLTO = 4.447858E-01
SINLTO = -8.956370E-01
PHIO = 2.007116E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-25.00	50.00	200.00	.323	-52.71	-28.83	60.00	1.00	-25.808	50.495	.319	1.359
-25.00	60.00	200.00	.341	-56.98	-27.37	60.00	1.00	-25.702	60.404	.353	-3.430
-25.00	70.00	200.00	.357	-60.59	-24.86	60.00	1.00	-25.624	70.321	.395	-9.599
-30.00	50.00	200.00	.341	-57.04	-30.60	60.00	1.00	-30.679	50.467	.320	6.443
-30.00	60.00	200.00	.359	-60.93	-29.34	60.00	1.00	-30.591	60.386	.359	.000
-30.00	70.00	200.00	.375	-64.28	-26.96	60.00	1.00	-30.524	70.310	.404	-7.347
-35.00	50.00	200.00	.358	-60.86	-32.79	60.00	1.00	-35.571	50.453	.325	10.253
-35.00	60.00	200.00	.376	-64.44	-31.81	60.00	1.00	-35.496	60.378	.366	2.514
-35.00	70.00	200.00	.391	-67.58	-29.62	60.00	1.00	-35.438	70.306	.414	-5.627

LOCATION OF POINT THAT IS FITTED

LATITUDE = -30.00 (DEG)
LONGITUDE = 120.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 9.357861E+10 GAUSS KM**3
COSLTO = 2.748684E-01
SINLTO = -9.614819E-01
PHIO = 2.091790E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-25.00	110.00	200.00	.498	-59.81	-3.55	60.00	1.00	-25.708	110.049	.498	.099
-25.00	120.00	200.00	.500	-60.05	.05	60.00	1.00	-25.702	119.999	.501	-.196
-25.00	130.00	200.00	.498	-59.79	3.66	60.00	1.00	-25.708	129.950	.499	-.107
-30.00	110.00	200.00	.526	-63.96	-3.86	60.00	1.00	-30.595	110.047	.522	.722
-30.00	120.00	200.00	.527	-64.19	.06	60.00	1.00	-30.591	119.999	.527	-.000
-30.00	130.00	200.00	.526	-63.95	3.97	60.00	1.00	-30.596	129.952	.527	-.134
-35.00	110.00	200.00	.552	-67.71	-4.25	60.00	1.00	-35.500	110.046	.544	1.535
-35.00	120.00	200.00	.554	-67.92	.07	60.00	1.00	-35.496	119.999	.551	.433
-35.00	130.00	200.00	.552	-67.70	4.38	60.00	1.00	-35.500	129.953	.552	.098

LOCATION OF POINT THAT IS FITTED

LATITUDE = -30.00 (DEG)
LONGITUDE = 180.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 9.165740E+10 GAUSS KM**3
COSLTO = 2.518176E-01
SINLTO = -9.678787E-01
PHIO = 2.730489E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-25.00	170.00	200.00	.445	-52.36	13.97	60.00	1.00	-25.907	169.749	.451	-1.354
-25.00	180.00	200.00	.432	-49.87	15.19	60.00	1.00	-25.984	179.703	.432	-.090
-25.00	190.00	200.00	.418	-47.05	15.89	60.00	1.00	-26.079	189.658	.413	1.230
-30.00	170.00	200.00	.472	-57.20	14.85	60.00	1.00	-30.758	169.766	.478	-1.239
-30.00	180.00	200.00	.459	-54.96	16.06	60.00	1.00	-30.819	179.725	.459	.000
-30.00	190.00	200.00	.445	-52.45	16.73	60.00	1.00	-30.893	189.687	.439	1.279
-35.00	170.00	200.00	.499	-61.49	15.98	60.00	1.00	-35.637	169.775	.503	-.880
-35.00	180.00	200.00	.486	-59.46	17.18	60.00	1.00	-35.667	179.738	.484	.317
-35.00	190.00	200.00	.472	-57.21	17.78	60.00	1.00	-35.746	189.705	.465	1.526

LOCATION OF POINT THAT IS FITTED

LATITUDE = -30.00 (DEG)
LONGITUDE = 240.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.957319E+10 GAUSS KM**3
COSLTO = 2.631284E-01
SINLTO = -9.647608E-01
PHIO = 2.337033E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-25.00	230.00	200.00	.337	-39.61	16.45	60.00	1.00	-26.380	229.545	.344	-1.972
-25.00	240.00	200.00	.326	-36.01	15.60	60.00	1.00	-26.565	239.511	.327	-.211
-25.00	250.00	200.00	.317	-32.43	14.36	60.00	1.00	-26.781	249.489	.310	2.435
-30.00	230.00	200.00	.358	-45.87	17.12	60.00	1.00	-31.116	229.598	.366	-1.980
-30.00	240.00	200.00	.347	-42.72	16.17	60.00	1.00	-31.246	239.577	.347	.000
-30.00	250.00	200.00	.337	-39.59	14.82	60.00	1.00	-31.392	249.568	.327	3.064
-35.00	230.00	200.00	.381	-51.37	17.98	60.00	1.00	-35.920	229.631	.390	-2.129
-35.00	240.00	200.00	.370	-48.62	16.90	60.00	1.00	-36.018	239.617	.369	.045
-35.00	250.00	200.00	.359	-45.90	15.42	60.00	1.00	-36.124	249.616	.347	3.465

LOCATION OF POINT THAT IS FITTED

LATITUDE = -60.00 (DEG)
LONGITUDE = -60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 6.886550E+10 GAUSS KM**3
COSLTO = 4.368574E-01
SINLTO = -8.995308E-01
PHIO = 2.466594E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-55.00	-70.00	200.00	.328	-50.81	15.45	60.00	1.00	-55.951	289.530	.331	-.951
-55.00	-60.00	200.00	.323	-49.37	10.60	60.00	1.00	-56.019	299.659	.313	3.084
-55.00	-50.00	200.00	.319	-48.44	5.65	60.00	1.00	-56.066	309.811	.301	6.128
-60.00	-70.00	200.00	.348	-55.79	16.37	60.00	1.00	-60.792	289.522	.361	-3.536
-60.00	-60.00	200.00	.343	-54.51	11.20	60.00	1.00	-60.846	299.656	.343	-.000
-60.00	-50.00	200.00	.340	-53.85	5.97	60.00	1.00	-60.882	309.811	.330	2.937
-65.00	-70.00	200.00	.368	-60.19	17.54	60.00	1.00	-65.665	289.489	.392	-6.079
-65.00	-60.00	200.00	.364	-59.24	11.98	60.00	1.00	-65.709	299.634	.376	-3.117
-65.00	-50.00	200.00	.361	-58.64	6.37	60.00	1.00	-65.738	309.799	.363	-.488

LOCATION OF POINT THAT IS FITTED

LATITUDE = -60.00 (DEG)
LONGITUDE = 0.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 5.909245E+10 GAUSS KM**3
COSLTO = 3.738403E-01
SINLTO = -9.274931E-01
PHIO = 2.331204E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-55.00	-10.00	200.00	.298	-55.41	-15.92	60.00	1.00	-55.805	350.409	.294	1.329
-55.00	0.00	200.00	.304	-57.13	-20.03	60.00	1.00	-55.738	.478	.297	2.362
-55.00	10.00	200.00	.312	-59.10	-23.95	60.00	1.00	-55.665	10.525	.303	3.040
-60.00	-10.00	200.00	.315	-59.88	-17.08	60.00	1.00	-60.676	350.423	.318	-.845
-60.00	0.00	200.00	.321	-61.30	-21.52	60.00	1.00	-60.620	.499	.321	-.000
-60.00	10.00	200.00	.328	-62.97	-25.86	60.00	1.00	-60.560	10.553	.327	.294
-65.00	-10.00	200.00	.332	-63.85	-18.47	60.00	1.00	-65.568	350.460	.347	-4.319
-65.00	0.00	200.00	.337	-65.02	-23.41	60.00	1.00	-65.521	.546	.350	-3.694
-65.00	10.00	200.00	.343	-66.41	-28.27	60.00	1.00	-65.469	10.609	.356	-3.671

LOCATION OF POINT THAT IS FITTED

LATITUDE = -60.00 (DEG)
LONGITUDE = 60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 7.437010E+10 GAUSS KM**3
COSLTO = 5.304905E-01
SINLTO = -8.476909E-01
PHIO = 2.487779E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-55.00	50.00	200.00	.406	-61.73	-46.36	60.00	1.00	-55.450	50.837	.382	6.279
-55.00	60.00	200.00	.425	-65.17	-50.75	60.00	1.00	-55.356	60.771	.420	1.119
-55.00	70.00	200.00	.443	-68.51	-54.89	60.00	1.00	-55.275	70.692	.461	-3.885
-60.00	50.00	200.00	.420	-64.42	-50.03	60.00	1.00	-60.373	50.907	.403	4.235
-60.00	60.00	200.00	.437	-67.40	-55.30	60.00	1.00	-60.287	60.845	.437	.000
-60.00	70.00	200.00	.454	-70.34	-60.53	60.00	1.00	-60.213	70.767	.473	-4.175
-65.00	50.00	200.00	.433	-66.74	-54.39	60.00	1.00	-65.303	51.023	.426	1.729
-65.00	60.00	200.00	.448	-69.27	-60.65	60.00	1.00	-65.224	60.964	.455	-1.541
-65.00	70.00	200.00	.462	-71.80	-67.08	60.00	1.00	-65.154	70.883	.485	-4.830

LOCATION OF POINT THAT IS FITTED

LATITUDE = -60.00 (DEG)
LONGITUDE = 120.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.648070E+10 GAUSS KM**3
COSLTO = 4.302325E-01
SINLTO = -9.027181E-01
PHIO = 2.408389E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-55.00	110.00	200.00	.591	-81.42	-44.35	60.00	1.00	-55.132	110.226	.590	.203
-55.00	120.00	200.00	.599	-83.39	-36.04	60.00	1.00	-55.115	120.146	.603	-.706
-55.00	130.00	200.00	.603	-84.80	-19.51	60.00	1.00	-55.105	130.065	.609	-1.006
-60.00	110.00	200.00	.598	-83.07	-58.79	60.00	1.00	-60.077	110.256	.590	1.218
-60.00	120.00	200.00	.604	-85.23	-53.87	60.00	1.00	-60.060	120.166	.604	.000
-60.00	130.00	200.00	.608	-87.07	-35.97	60.00	1.00	-60.051	130.074	.612	-.555
-65.00	110.00	200.00	.601	-84.01	-79.56	60.00	1.00	-65.023	110.300	.587	2.342
-65.00	120.00	200.00	.606	-86.15	-85.42	60.00	1.00	-65.006	120.195	.601	.968
-65.00	130.00	200.00	.610	-88.28	-94.43	60.00	1.00	-64.997	130.087	.609	.153

LOCATION OF POINT THAT IS FITTED

LATITUDE = -60.00 (DEG)
LONGITUDE = 180.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MU0 = 8.716633E+10 GAUSS KM**3
COSLT0 = 3.3852A1E-01
SINLT0 = -9.409563E-01
PHI0 = 2.281895F+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGHF B	PERCENT
-55.00	170.00	200.00	.579	-78.07	33.39	60.00	1.00	-55.216	169.750	.581	-.315
-55.00	180.00	200.00	.569	-76.20	35.56	60.00	1.00	-55.245	179.693	.568	.217
-55.00	190.00	200.00	.556	-74.18	38.17	60.00	1.00	-55.280	189.640	.553	.626
-60.00	170.00	200.00	.5[illegible]	-[illegible].27	41.34	60.00	1.00	-60.158	169.721	.593	-.356
-60.00	180.00	200.00	.581	-78.42	42.58	60.00	1.00	-60.185	179.658	.581	-.000
-60.00	190.00	200.00	.570	-76.50	42.22	60.00	1.00	-60.218	189.602	.569	.321
-65.00	170.00	200.00	.599	-82.10	53.23	60.00	1.00	-65.102	169.676	.599	-.083
-65.00	180.00	200.00	.591	-80.29	52.41	60.00	1.00	-65.128	179.605	.590	.115
-65.00	190.00	200.00	.582	-78.47	50.38	60.00	1.00	-65.159	189.541	.579	.368

LOCATION OF POINT THAT IS FITTED

LATITUDE = -60.00 (DEG)
LONGITUDE = 240.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MU0 = 8.280516E+10 GAUSS KM**3
COSLT0 = 8.034215E-01
SINLT0 = -9.150143E-01
PHI0 = 2.869823E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGHF B	PERCENT
-55.00	230.00	200.00	.481	-66.57	38.00	60.00	1.00	-55.416	229.425	.486	-.888
-55.00	240.00	200.00	.465	-63.97	34.82	60.00	1.00	-55.488	239.399	.464	.399
-55.00	250.00	200.00	.450	-61.42	31.29	60.00	1.00	-55.567	249.389	.438	2.699
-60.00	230.00	200.00	.499	-69.30	41.97	60.00	1.00	-60.343	229.375	.505	-1.366
-60.00	240.00	200.00	.484	-67.02	38.09	60.00	1.00	-60.407	239.352	.484	-.000
-60.00	250.00	200.00	.471	-64.82	33.95	60.00	1.00	-60.475	249.349	.460	2.194
-65.00	230.00	200.00	.513	-71.68	46.92	60.00	1.00	-65.275	229.292	.522	-1.549
-65.00	240.00	200.00	.501	-69.71	42.16	60.00	1.00	-65.334	239.272	.502	-.180
-65.00	250.00	200.00	.489	-67.83	37.28	60.00	1.00	-65.395	249.275	.481	1.824

LOCATION OF POINT THAT IS FITTED

LATITUDE = -85.00 (DEG)
LONGITUDE = -60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.100570E+10 GAUSS KM**3
COSLTO = 4.056139E-01
SINLTO = -8.685430E-01
PHIO = 2.413075E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-80.00	-70.00	200.00	.484	-68.74	31.04	60.00	1.00	-80.405	288.526	.480	.911
-80.00	-60.00	200.00	.481	-68.18	23.15	60.00	1.00	-80.449	298.839	.472	1.942
-80.00	-50.00	200.00	.478	-67.78	15.32	60.00	1.00	-80.481	309.201	.465	2.914
-85.00	-70.00	200.00	.502	-71.56	34.81	60.00	1.00	-85.330	287.135	.504	-.485
-85.00	-60.00	200.00	.500	-71.28	25.97	60.00	1.00	-85.370	297.747	.500	-.000
-85.00	-50.00	200.00	.499	-71.07	17.19	60.00	1.00	-85.400	308.451	.496	.451
-90.00	-70.00	200.00	.517	-74.08	39.72	60.00	1.00	-89.650	149.718	.525	-1.607
-90.00	-60.00	200.00	.517	-74.08	29.72	60.00	1.00	-89.650	149.718	.525	-1.607
-90.00	-50.00	200.00	.517	-74.08	19.72	60.00	1.00	-89.650	149.718	.525	-1.607

LOCATION OF POINT THAT IS FITTED

LATITUDE = -85.00 (DEG)
LONGITUDE = 0.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.002490E+10 GAUSS KM**3
COSLTO = 5.027550E-01
SINLTO = -8.644290E-01
PHIO = 2.423186E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-80.00	-10.00	200.00	.471	-67.44	-15.38	60.00	1.00	-80.489	350.816	.454	3.669
-80.00	0.00	200.00	.473	-67.85	-23.24	60.00	1.00	-80.456	1.185	.456	3.790
-80.00	10.00	200.00	.476	-68.41	-31.16	60.00	1.00	-80.411	11.505	.460	3.676
-85.00	-10.00	200.00	.491	-70.75	-17.22	60.00	1.00	-85.407	351.581	.491	-.046
-85.00	0.00	200.00	.492	-70.97	-26.02	60.00	1.00	-85.376	2.300	.492	-.000
-85.00	10.00	200.00	.494	-71.20	-34.88	60.00	1.00	-85.335	12.924	.494	-.057
-90.00	-10.00	200.00	.509	-73.79	-19.70	60.00	1.00	-89.644	150.297	.525	-3.118
-90.00	0.00	200.00	.509	-73.79	-29.70	60.00	1.00	-89.644	150.297	.525	-3.118
-90.00	10.00	200.00	.509	-73.79	-39.70	60.00	1.00	-89.644	150.297	.525	-3.118

LOCATION OF POINT THAT IS FITTED

LATITUDE = -85.00 (DEG)
LONGITUDE = 60.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.149662E+10 GAUSS KM**3
COSLTO = 5.058555E-01
SINLTO = -8.626182E-01
PHIO = 2.620106E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-80.00	50.00	200.00	.505	-71.70	-64.52	60.00	1.00	-80.168	52.142	.492	2.726
-80.00	60.00	200.00	.512	-72.74	-73.40	60.00	1.00	-80.102	62.123	.503	1.664
-80.00	70.00	200.00	.518	-73.80	-82.65	60.00	1.00	-80.039	72.043	.515	.557
-85.00	50.00	200.00	.513	-72.89	-71.80	60.00	1.00	-85.105	54.203	.510	.462
-85.00	60.00	200.00	.516	-73.42	-81.43	60.00	1.00	-85.041	64.177	.516	-.000
-85.00	70.00	200.00	.519	-73.96	-91.30	60.00	1.00	-84.980	76.030	.522	-.494
-90.00	50.00	200.00	.517	-73.66	-79.88	60.00	1.00	-89.641	150.121	.525	-1.479
-90.00	60.00	200.00	.517	-73.66	-89.88	60.00	1.00	-89.641	150.121	.525	-1.479
-90.00	70.00	200.00	.517	-73.66	-80.12	60.00	1.00	-89.641	150.121	.525	-1.479

LOCATION OF POINT THAT IS FITTED

LATITUDE = -85.00 (DEG)
LONGITUDE = 120.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MUO = 8.335695E+10 GAUSS KM**3
COSLTO = 8.922684E-01
SINLTO = -8.704435E-01
PHIO = 2.401215E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-80.00	110.00	200.00	.555	-78.28	-126.02	60.00	1.00	-79.848	111.168	.558	-.521
-80.00	120.00	200.00	.559	-78.99	-138.77	60.00	1.00	-79.819	120.890	.566	-1.223
-80.00	130.00	200.00	.561	-79.53	-152.40	60.00	1.00	-79.799	130.593	.572	-1.776
-85.00	110.00	200.00	.545	-76.42	-134.53	60.00	1.00	-84.788	112.325	.543	.413
-85.00	120.00	200.00	.547	-76.75	-145.90	60.00	1.00	-84.758	121.773	.547	-.000
-85.00	130.00	200.00	.548	-76.98	-157.50	60.00	1.00	-84.737	131.183	.550	-.353
-90.00	110.00	200.00	.532	-74.21	-140.96	60.00	1.00	-89.653	149.039	.525	1.402
-90.00	120.00	200.00	.532	-74.21	-150.96	60.00	1.00	-89.653	149.039	.525	1.402
-90.00	130.00	200.00	.532	-74.21	-160.96	60.00	1.00	-89.653	149.039	.525	1.402

LOCATION OF POINT THAT IS FITTED

LATITUDE = -85.00 (DEG)
LONGITUDE = 180.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MU0 = 8.386501E+10 GAUSS KM**3
COSLT0 = 4.775595E-01
SINLT0 = -8.785904E-01
PHI0 = 2.587459E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-80.00	170.00	200.00	.567	-79.93	148.10	60.00	1.00	-79.814	169.348	.577	-1.767
-80.00	180.00	200.00	.564	-79.33	134.55	60.00	1.00	-79.837	179.066	.574	-1.770
-80.00	190.00	200.00	.560	-78.57	121.95	60.00	1.00	-79.867	188.804	.570	-1.685
-85.00	170.00	200.00	.554	-77.48	154.15	60.00	1.00	-84.754	168.701	.554	.021
-85.00	180.00	200.00	.553	-77.22	142.54	60.00	1.00	-84.776	178.141	.553	-.000
-85.00	190.00	200.00	.551	-76.88	131.20	60.00	1.00	-84.807	187.622	.551	.050
-90.00	170.00	200.00	.539	-74.80	158.25	60.00	1.00	-89.667	148.250	.525	2.685
-90.00	180.00	200.00	.539	-74.80	148.25	60.00	1.00	-89.667	148.250	.525	2.685
-90.00	190.00	200.00	.539	-74.80	138.25	60.00	1.00	-89.667	148.250	.525	2.685

LOCATION OF POINT THAT IS FITTED

LATITUDE = -85.00 (DEG)
LONGITUDE = 240.00 (DEG)
ALTITUDE = 200.00 (DEG)
TIME = 1975.00 (YRS)

FITTED DIPOLE PARAMETERS

MU0 = 8.295032E+10 GAUSS KM**3
COSLT0 = 4.835432E-01
SINLT0 = -8.753205E-01
PHI0 = 2.596884E+00 LONGITUDE EAST (RADIANS)

TEST LAT	TEST LON	TEST ALT	DIPOLE B	DIPANG	DECANG	INTERS ALT	AJUG	INTERS LAT	INTERS LON	IGRF B	PERCENT
-80.00	230.00	200.00	.532	-74.53	80.59	60.00	1.00	-80.050	228.062	.540	-1.567
-80.00	240.00	200.00	.525	-73.49	71.47	60.00	1.00	-80.110	237.995	.530	-.925
-80.00	250.00	200.00	.519	-72.49	62.72	60.00	1.00	-80.171	247.987	.520	-.147
-85.00	230.00	200.00	.533	-74.78	89.68	60.00	1.00	-84.991	226.178	.535	-.377
-85.00	240.00	200.00	.530	-74.26	79.86	60.00	1.00	-85.049	236.055	.530	-.000
-85.00	250.00	200.00	.527	-73.74	70.29	60.00	1.00	-85.109	246.050	.525	.433
-90.00	230.00	200.00	.532	-74.56	81.21	60.00	1.00	-89.661	148.791	.525	1.301
-90.00	240.00	200.00	.532	-74.56	88.79	60.00	1.00	-89.661	148.791	.525	1.301
-90.00	250.00	200.00	.532	-74.56	78.79	60.00	1.00	-89.661	148.791	.525	1.301

END OF TEST PROBLEM

Table A8. Summary of Running Time Experience for Ambient Magnetic Field Module on a CDC 7600 Computer.

Timing runs have been made for the various subroutines in the ambient magnetic field model, with the following results obtained on the Berkeley CDC 7600 computer:

MAGFIT (includes call to ONEMG5)	0.30 msec[a] or 0.64 msec[b]
BFIELD	0.055 msec
CONJUG	0.067 msec[c]
ONEMG5	0.21 msec[a] or 0.56 msec[b]

[a] For a 6-page Fortran version containing no DO-loops.

[b] For a 2-page Fortran version containing DO-loops.

[c] This number should be contrasted with a value of 26.7 msec required if ONEMG5 (i.e., the multipole field) were used instead of BFIELD (i.e., the dipole field) in tracing the field line to the conjugate region.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Director
Defense Advanced Research Proj. Agency
ATTN: STO

Defense Communication Engineer Center
ATTN: Code R410, James W. McLean

Director
Defense Communications Agency
ATTN: Code 480

Defense Documentation Center
Cameron Station
12 cy ATTN: TC

Director
Defense Nuclear Agency
ATTN: DDST
ATTN: TISI, Archives
3 cy ATTN: TITL, Tech. Library
ATTN: RAAE

Dir. of Defense Research & Engineering
Department of Defense
ATTN: S&SS (OS)

Commander
Field Command
Defense Nuclear Agency
ATTN: FCPR

Director
Interservice Nuclear Weapons School
ATTN: Document Control

Director
Joint Strat. Target Planning Staff, JCS
ATTN: JPST, Captain G. D. Goetz

Chief
Livermore Division, Field Command, DNA
Lawrence Livermore Laboratory
ATTN: FCPRL

DEPARTMENT OF THE ARMY

Commander/Director
Atmospheric Sciences Laboratory
US Army Electronics Command
ATTN: DRSEL-BL-SY-S, F. E. Niles

Director
BMD Advanced Tech. Center
Huntsville Office
2 cy ATTN: ATC-T, Melvin T. Capps

Commander
Harry Diamond Laboratories
ATTN: DRXDO-NP, Francis N. Wimenitz
ATTN: DRXDO-TI

Director
TRASANA
ATTN: R. E. DeKinder, Jr.

DEPARTMENT OF THE ARMY (Continued)

Director
US Army Ballistic Research Labs.
ATTN: Lawrence J. Puckett
ATTN: Mark D. Kregel

Commander
US Army Foreign Science & Tech. Center
ATTN: P. A. Crowley

Commander
US Army Missile Intelligence Agency
ATTN: Jim Gamble

Commander
US Army Missile Command
ATTN: DRSMI-XS, Chief Scientist

Commander
US Army Nuclear Agency
ATTN: MONA-WE, J. Berberet

DEPARTMENT OF THE NAVY

Chief of Naval Operations
Navy Department
ATTN: Alexander Brandt

Commander
Naval Ocean Systems Center
3 cy ATTN: Code 2200, Verne E. Hildebrand

Director
Naval Research Laboratory
3 cy ATTN: Code 7701, Jack D. Brown
ATTN: Code 7750, S. Ossakow

Commander
Naval Surface Weapons Center
ATTN: Code WA501, Navy Nuc. Prgms. Off.
ATTN: Code WX21, Tech. Lib.

Director
Strategic Systems Project Office
Navy Department
ATTN: NSP-2772, Marcus Meserole
ATTN: NSSP-2722, Fred Wimberly

DEPARTMENT OF THE AIR FORCE

AF Geophysics Laboratory, AFSC
ATTN: OPR, James C. Ulwick
ATTN: OPR, Alva T. Stair
ATTN: OPR, Harold Gardner

AF Weapons Laboratory, AFSC
ATTN: NSS, John M. Kamm
ATTN: SUL
ATTN: DYT, Captain Mark A. Fry
ATTN: DYT, Captain L. Wittwer
ATTN: DYT, Peter W. Lunn

Hq. USAF/RD
ATTN: RDQSM

DEPARTMENT OF THE AIR FORCE (Continued)

Commander
Rome Air Development Center, AFSC
ATTN: EMTLD, Doc. Library

SAMSO/SZ
ATTN: SZJ, Major Lawrence Doan

Commander in Chief
Strategic Air Command
ATTN: ADWATE, Captain Bruce Bauer
ATTN: XPFS, Major Brian G. Stephan

Hq. USAF/SA
ATTN: AFSA, Captain Henkle

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION

University of California
Lawrence Livermore Laboratory
ATTN: Ralph S. Hager, L-31
ATTN: Donald R. Dunn, L-156

Los Alamos Scientific Laboratory
ATTN: Doc. Con. for John Zinn
ATTN: Doc. Con. for Eric Jones

OTHER GOVERNMENT AGENCIES

Department of Commerce
Office of Telecommunications
Institute for Telecom Science
ATTN: William F. Utlaut

DEPARTMENT OF DEFENSE CONTRACTORS

Aerospace Corporation
ATTN: Norman D. Stockwell
ATTN: Doug Rawcliffe

Brown Engineering Company, Inc.
ATTN: James E. Cato
ATTN: Romeo DeLiberis
ATTN: Joel D. Bigley

ESL, Inc.
ATTN: James Marshall
ATTN: C. Prettie

General Electric Company
TEMPO-Center for Advanced Studies
ATTN: Warren S. Knapp
ATTN: Tim Stephens
ATTN: DASIAC

General Research Corporation
ATTN: John Ise, Jr.
ATTN: Joel Garbarino

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Jaycor
ATTN: S. R. Goldman

Johns Hopkins University
Applied Physics Laboratory
ATTN: Document Librarian

Lockheed Missiles & Space Company, Inc.
ATTN: D. R. Churchill

M.I.T. Lincoln Laboratory
ATTN: Lib. A-082 for David M. Towle

Martin Marietta Aerospace
Orlando Division
ATTN: Roy W. Heffner

Mission Research Corporation
ATTN: D. Sappenfield
ATTN: R. Bogusch
ATTN: R. Hendrick
ATTN: Russell Christian
ATTN: W. F. Crevier
ATTN: R. W. Kilb
ATTN: A. H. Michelet

Physical Dynamics, Inc.
ATTN: Joseph B. Workman

R & D Associates
ATTN: Bryan Gabbard
ATTN: Robert E. LeLevier

Science Applications, Inc.
ATTN: D. Sachs
ATTN: Curtis A. Smith
ATTN: Daniel A. Hamlin
ATTN: Robert W. Lowen
ATTN: Melvin R. Schoonover

Science Applications, Inc.
Huntsville Division
ATTN: Dale H. Divis
ATTN: Noel R. Byrn

Stanford Research Institute
ATTN: Walter G. Chestnut

VisiDyne, Inc.
ATTN: J. W. Carpenter
ATTN: Charles Humphrey